ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. LII. No. 24. New York, December 15, 1904.

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THE ERECTION OF THE NEW FERRY BRIDGE AT DULUTH, MINN.

We described in our issue of March 20, 1902, the design and construction of a proposed ferry bridge to be built across the ship canal entrance to Duluth Harbor. There were a number of delays in beginning the construction of this bridge, but it has now reached the point where erection is well advanced, and through the courtesy of Mr. C. A. P. Turner, M. Am. Soc. C. E., we are able to publish a view of the structure as it looked recently and one which shows quite clearly the method of erection adopted. The following communication has been sent us by Mr. Turner, with the photograph:

Sir: I send you herewith a photograph of the Duluth Ferry Bridge in course of erection. The center chords are being placed to-day, Nov. 14. The photograph illustrates clearly the novel cantilever method of erection, involving a three-point support and three-level adjustment required. The features of the design and erection will shortly be discussed in a paper by the writer to be presented to the American Society of Civil Engineers.

The Modern Steel Structural Co., of Waukesha, Wis., was the only bridge concern in the country that the writer personally could find for the City of Duluth possessing sufficient nerve and engineering ability to tackle the construction at the figure available. The President of this company, Mr. S. B. Harding, is an exceptionally able engineer, and this fact accounts for the rational view taken by them of the difficulties involved in the work. The structure with some very slight modification by Mr. Harding for the purpose of reducing the cost of machine parts is being built according to the plans of the writer.

The work has been erected by the same company, Mr. J. K. Lowry, secretary of the company, taking charge of the work, assisted by such advice as the president of the company and the designer could offer to facilitate the work.

The shop work throughout is of the highest order—in fact the best the writer has seen in the course of his long experience in the business.

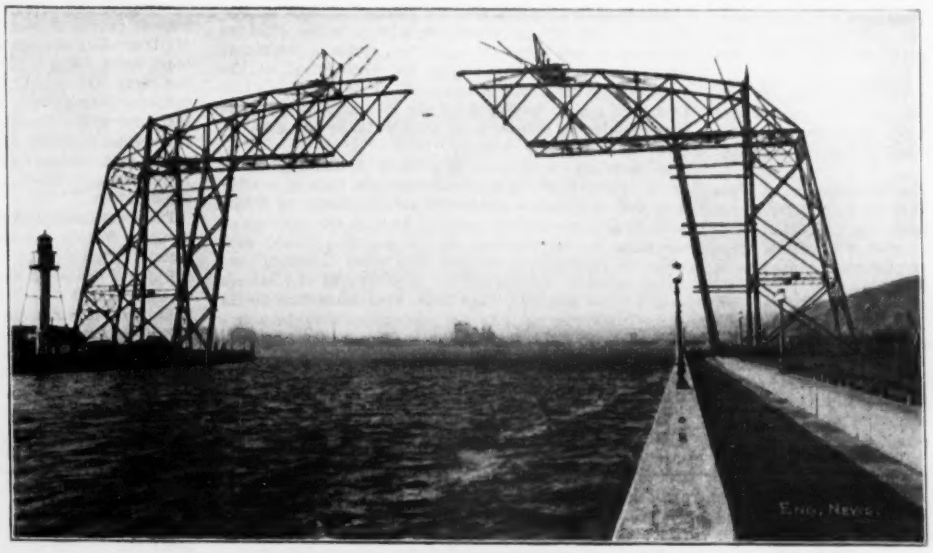
In part credit for this is in fairness due to the thorough inspection of the Pittsburg Testing Laboratory Co., who have made a most commendable effort to assist the manufacturers in thoroughly checking up all connections as the total absence of misfits in the field has shown.

This company took the inspection at a lower figure than the writer considered they could do the work for at a profit, and upon being advised of the fact immediately responded that the work should be thoroughly done regardless of expense.

To Mr. Thos. F. McGilvray, City Engineer of Duluth, is due full credit for conception of the idea of a suspended car transfer across the canal, while the writer assumes to the extent his advice is followed, the professional credit or discredit of design and promotion of the construction.

Respectfully yours,

C. A. P. Turner, M. Am. Soc. C. E.



VIEW OF FERRY BRIDGE ACROSS THE DULUTH SHIP CANAL, SHOWING METHOD OF ERECTION.

SOME REFINEMENTS OF MECHANICAL SCIENCE.*

By Ambrose Swasey,† M. Am. Soc. M. E.

I wish to speak of a few of those methods and mechanisms which have been developed and perfected to such a degree of refinement that they may be considered as almost beyond the practical, and yet were it not for such refinements they could not possibly be made to serve the utilitarian purposes which make them of such inestimable value to us all.

The division and the measurement of time is to-day, as it has been for ages, among the most important of the subjects affecting the welfare of mankind.

The diurnal revolution of the earth, which gives the solar day, and the revolution of the earth around the sun, the solar year, are the arbitrary divisions of time marked off with the utmost precision by the celestial bodies; and while the length of the solar day has, from before the Christian Era, been fairly well defined, the length of the solar year was but approximately known until within a few hundred years.

The length of the year as counted by the Julian calendar was too long by 11 minutes and 14 seconds, and this error amounted to ten full days in the 1,600 years from the time the Julian calendar went into effect until the introduction of the Gregorian calendar.

A few years ago, when visiting the Vatican Observatory, I was particularly interested in the Gregorian Tower, which forms a part of the Vatican Library Building. After passing through a number of rooms which are used in connection with the Observatory, when near the top of the tower, I was taken into the spacious and beautiful calendar room, the walls of which are covered with paintings of the highest order, executed centuries ago, under the direction of Pope Gregory XIII. In the center of the room, and forming a part of the floor, there was a large marble slab, on which was cut a fine line exactly in the true meridian, and upon the line was a special mark which indicated the altitude of the sun at noon of a certain day. On the south wall, near the top of the room, there was a small aperture through which the direct rays of the sun passed at noon, projecting a bright spot on the meridian line.

All of this had been planned and executed by the astronomers in order that they might demonstrate the necessity of reforming the calendar, and when at noon on the 23d of March, 1582, Pope Gregory saw that the altitude of the sun as shown by the beam of light was not for that particular day, but for the day ten days previous, he directed that ten days be stricken from the calendar and that day should be the 11th of March instead of the 23d.

With such precision had the astronomers determined the true length of the year, that our present calendar with its intercalations will continue on for 20,000 years with an error not to exceed a single day.

Since an unknown time the day has been divided into 24 hours, and as civilization has advanced, the greater has been the necessity for the utmost precision in the measurement of each hour, with its subdivisions.

The sun dial is not only the earliest, but the most interesting of all the numerous arrangements that have been devised for measuring the divisions of the day. Notwithstanding its limitations, it has been a subject which has attracted the brightest minds for ages. Within these later years there has been a renewed interest in this ancient timekeeper, not only in copying the types of dials, which are valuable because of their antiquity, but in working out new forms. Recently a new dial has been invented by which the rays of the sun will indicate the true mean time for each day of the year, with an error not to exceed one minute.

The hour glass, which came later, was considered a much more practical method, inasmuch as it could be used either day or night, and because its use was not confined to a particular location, however, as a timekeeper it was not satisfactory, even in those early days.

The clepsydra or water clock, which is supposed to have been invented by the Greeks, was found to be a much better timekeeper than either the sun dial or hour glass, and it was a great step in advance toward the accurate measurement of time.

These water clocks are to this day used extensively in the East, more especially in China. Those first used by the Greeks consisted of two water jars so arranged that the water from the upper ran into the lower, and the time of day was determined by measuring the depth of water in the upper jar, and at sunrise each day the water was returned to the upper jar. In the city of Canton there is a water clock which has been running for 900 years, and at the present time it is the standard clock of that city.

This clock consists of four water jars, each having a capacity of eight or ten gallons. The jars are placed one above the other in the form of a terrace, the three upper ones being provided with a small orifice near the bottom, through which the water drops into the jar next below, and so on down from one to the other, until the water reaches the lowest or registering jar. In this there is a float, to which is attached an upright having graduations

*From the Presidential address at the New York meeting of the American Society of Mechanical Engineers.

†Vice-President and Treasurer, the Warner & Swasey Co., Cleveland, O.

for the hours and parts of hours, and as the water rises the time can be determined by noting the height of the float in relation to the crossbar at the top of the jar.

In this improved form of water clock the variation in the flow of water due to the difference in height is overcome by having a series of jars, the outlet of the upper being so graduated that there is but little variation in the height of water in the second jar, and in the third the height remains practically uniform, thus insuring a constant head for the water which drops into the registering jar. At the beginning of each day the water is taken from below and carried up a flight of steps to the top.

Clocks of the present type, although used as far back as the twelfth century and possibly earlier, were but fair timekeepers until several centuries later. Those which the astronomers used in the observatories at the end of the fifteenth century were so unreliable that modified forms of the clepsydras of the ancients were used, and as they did not prove to be satisfactory, most of the observations were made without the use of clocks.

Galileo's beautiful discovery of the isochronism of the pendulum from the swinging chandelier in the church at Pisa was of great value in many respects, but in none more so than in its application to the measurement of time.

Soon after that great discovery, the English clockmaker, Graham, invented the mercurial pendulum, by which the variation in its length caused by the difference in temperature was fully compensated, and some years later Harrison, another English clockmaker, invented a compensating pendulum, which consisted of a series of metal bars having different coefficients of expansion—so that two hundred years ago, as it is to-day, the pendulum was the nearest perfect of all the devices that have been employed for governing or controlling the motions of a clock mechanism.

Every part of the clock down to the minutest detail has been the subject of study and improvement, and they are made and adjusted with such precision and delicacy that in testing them the question is, within how small a fraction of a second will they run? Not content with their marvelous performance when under normal conditions, some of the finest astronomical clocks are surrounded by glass or metal cases, in which a partial vacuum is maintained, and in order that the cases may not be opened or disturbed, the winding is done automatically by means of electricity; the frequency of the winding in some cases being as often as once every minute. These clocks are set up in especially constructed rooms or underground vaults, where they are free from jar or vibration, where the temperature and barometric conditions remain practically constant, and where every possible precaution is taken to further minimize the errors of the running rate.

A clock in the Observatory at Berlin has run for several months under these favorable conditions, with a rate having a mean error of but fifteen one-thousandths of a second per day and a maximum error of thirty one-thousandths of a second per day.

Another clock installed at the Observatory of Case School of Applied Science at Cleveland, running under similar conditions, also has a mean error of fifteen one-thousandths of a second per day, with a maximum error for several months of but twenty-two one-thousandths of a second per day.

From the time of the invention of Peter Hele, in 1477, of the "Nuremberg Animated Egg" or "pocket clock," which required winding twice a day and varied an hour and a half in the same length of time, the development of the watch has kept pace with the "Mother Clock," and followed closely to it in timekeeping qualities.

The larger watch, or ship chronometer, with its escapement so delicately made and adjusted that it must always be kept in the same position, was greatly improved through the efforts of the British Government in 1714 by offering rewards of ten, fifteen and twenty thousand pounds to any who should make chronometers that would run so accurately that the longitude of a ship at sea could be determined within sixty, forty and thirty miles, and Harrison, the inventor of the compensating pendulum and the compensating balance, which is now used in watches, succeeded in making a chronometer, which, after being tested on a long voyage, was found to run so closely that the position of the ship was determined within eighteen miles, and he was therefore paid the full award of £20,000. That historic chronometer, which marked a new era in navigation, is now numbered among the treasures of Greenwich Observatory.

Long before the telescope was invented, Tycho Brahe, the Danish astronomer, "the founder of Modern Astronomy," constructed for his observatory, instruments of various kinds having graduated circles and arcs of circles. His instruments for the most part were improvements on those used by Arabian astronomers in the eighth and ninth centuries, and these in turn were copied after similar instruments used by the Greeks and Egyptians a thousand years previous, and it is supposed that such instruments were used by the Chinese at an even earlier period, so that graduated circles have come down to us from the far-off ages.

The longer the radius the more accurate the graduations was the principle upon which the early instruments were made. The Arabians, in about the year 1,000, built a sextant with a 60-ft. radius and a quadrant with a 21-ft. radius, but to Tycho Brahe is due the credit of constructing instruments having circles much smaller in diameter and graduated with a greater precision than ever before. It was by the use of such improved instruments of his own making, and by his observations which were made without a telescope or any means of magnification, that he was able to give the positions of a large number of stars within less than one minute of arc from the positions given by modern astronomers.

The graduation of an eight-foot mural circle in 1725 by Graham, of England, for the National Observatory, and of an eight-foot quadrant by Bird, in 1767, were notable steps in advance in the division of the circle and the measurement of angles, but these and similar instruments, although their efficiency was greatly augmented by the use of the telescope, have been supplanted by others more practical.

The first circular dividing engine was made in 1740 by Henry Hindley, of New York, for cutting the teeth of clock wheels, and it is interesting to note that in the same year Huntsmann, another clockmaker, of Sheffield, invented the process of making crucible steel, that he might have a metal suitable for the springs of his clocks.

Of the several engines constructed later, the one most successful and representing the greatest progress was that made by Ramsden, in 1777. This engine, automatic in its movements, was made especially for graduating circles, and because of the great precision with which he divided the circles of the instrument used by the government, the Board of Longitude awarded him the sum of £615. A further and most potent recognition of the excellence of his work lies in the fact that all subsequent circular dividing engines have followed closely the same general principles of construction embodied in the Ramsden engine.

It is most gratifying to all those who are interested in mechanical progress that the Ramsden engine has been preserved throughout all these years, and it now stands in the Museum of the Smithsonian Institution, at Washington, as a monument to the one who made it and as the best example of that time of the art of graduating circles.

The graduation of circles for astronomical instruments is one of the most difficult of all mechanical problems.

In such an engine the chief essential is that the spindle carrying the master plate shall be as nearly round and as closely fitted in its bearings as is possible, for the degree of excellence with which that work is done determines how closely a circle can be divided.

The greatest accuracy thus far attained in such engines is one second of arc, which arc with a radius of three miles equals one inch, and at 20 ins., which is the radius of the silver ring upon which the graduations on the master plate are made, a line 0.001-in. in width is equal to 12" of arc, or twelve times the accumulated errors of any number of divisions, or twenty times the greatest error of any single division.

In automatically graduating a circle, it has been found to be impracticable to cut more than six lines in a minute, and it requires about thirty-three hours to divide a circle into two-minute spaces. As with the running of the finest clocks, the best results can be obtained only when the engine is surrounded with every favorable condition possible. Instead of the large circles and sectors used by the ancients, they have been made smaller in diameter as the methods for graduating have been improved, until those of the more modern instruments are seldom more than 30 ins., and some of the latest meridian instruments have circles of but 25 ins.

The smaller circles, which can be made and graduated with greater precision than the larger ones, are also less liable to change in form, owing to their weight and the variation in temperature, and with the aid of the reading microscope the results obtained would not be possible with the larger circles.

A 25-in. circle read with a microscope having a power of 40, would be equivalent to a circle of about 80 feet in diameter, and a single second of arc as seen through the microscope would be equal to 0.0024 in., a quantity easily subdivided.

A most important adjunct to the astronomer's instrumental equipment is the filar micrometer. With it he determines the errors of divisions, the eccentricity of his circle and measures the angles to within a fraction of a second; and when used at the eye end of the telescope he determines the positions and motions of the stars and the distance and diameters of the planets. In these little instruments, whether of the simple or complex form, the chief requisites are the screw and the cross wires, for upon them the value of the observations and measurements depend.

To make the screw of a micrometer so true that the errors in the threads cannot be detected by its own magnifying power is an extremely difficult task. These micrometer screws are often made with one hundred threads to the inch, and are provided with graduated drums having 100 divisions, the readings being made in tenths of a division.

The cross wires, which are but common spider lines, because of their fineness and the remarkable qualities they possess, are indispensable in micrometric work.

The spider lines mostly used are from one-fifth to one-seventh of a thousandth of an inch in diameter, and in addition to their strength and elasticity, they have the peculiar property of withstanding great changes of temperature, and often when measuring the sun spots, although the heat is so intense as to crack the lenses of the micrometer eye piece, yet the spider lines are not in the least injured.

The threads of the silk worm, although of great value as a commercial product, are so coarse and rough compared with the silk of the spider that they cannot be used in such instruments. Platinum wires are made sufficiently fine and make most excellent cross wires for instruments where low magnifying powers are used, yet as the power increases they become rough and imperfect.

Spider lines, although of but a fraction of a thousandth of an inch in diameter, are made up of several thousand of microscopic streams of fluid, which unite and form a single line, and it is because of this that they remain true and round under the highest magnifying power.

An instance of the durability of the spider lines is found at the Allegheny Observatory, where the same set of lines in the micrometer of the transit instrument has been in use since 1859.

The placing of the spider lines in the micrometer is a work of great delicacy, and in some micrometers there are as many as thirty which form a reticule, with lines two one-thousandths of an inch apart, and parallel with each other, under the highest magnifying power.

In the realm of the measurements of minute linear distances, and the perfection of curved and flat surfaces, the refinements are even greater than those pertaining to the measurement of time and of angles.

Most important in the linear dividing engine is the screw, and although much had been accomplished in bringing such engines to a high degree of excellence, it was for Professor Rowland to make an engine which has a practically perfect screw; and without doubt it is to all respects the nearest perfect of all the mechanisms that have been employed for ruling lines exactly parallel and equally spaced.

The Rowland engine was made specially for ruling diffraction gratings which are made of speculum metal, and with it a metal surface has been ruled with 160,000 lines, there being about 29,000 to the inch, and as many as 43,000 lines to the inch have been ruled.

The gratings mostly used have from 14,000 to 20,000 lines to the inch, and with such exactness is the cutting tool moved by the screw that the greatest error in the ruling does not exceed one millionth of an inch.

The production of these gratings, which has enabled the physicist in his study of the spectrum to enter fields of research before unknown, has not only called for the highest degree of perfection ever attained in the spacing of linear distances, but it has also called for a refinement most difficult in the optical surfaces upon which the lines are ruled. To Mr. Brashear was given the problem of producing such surfaces, and notwithstanding the many difficulties encountered in working and refining the speculum metal plates, he has made many hundred plates with surfaces either flat or curved with an error not to exceed one-tenth of a wave length of light, or 0.0000025 in.

The established standards of length which are the yard of Great Britain and the meter of France, being made of metal, and liable to destruction or damage Professor Michelson conceived the idea of determining the lengths of these standards in wave lengths of light, which would be a basis of value unalterable and indestructible.

For the purpose of carrying out these experiments, the interferometer was constructed, an instrument which required the highest order of workmanship and the greatest skill of the optician. Again Mr. Brashear proved to be equal to the occasion, and made for the instrument a series of refracting plates, the surfaces of which were flat within one-twentieth of a wave length of light, with sides parallel within one second. This was the most difficult work ever attempted in the refinement of optical surfaces.

Professors Michelson and Morley devised a method for using the interferometer, for making the wave length of some definite light an actual and practical standard of length. So satisfactory was the result that Professor Michelson was invited to continue the experiments at the Bureau of Weights and Measures, at Sèvres, France, where the standard meter, which is kept in an underground vault and inspected only at long intervals, was used for that important work, which occupied nearly a year. The final result of the experiments shows that there are 1,553,164.5 wave lengths of red cadmium light in the French standard meter, at 15° C. So great is the accuracy of these experiments that they can be repeated within one part in two millions. Should the material standard of length be damaged or destroyed, the standard wave length of light will remain unaltered, as a basis from which an exact duplicate of the original standard can be made.

THE BLACKWELL'S ISLAND BRIDGE is to carry six railway tracks instead of four. The Board of Estimate and Apportionment of New York City has authorized the Bridge Commissioner to change the plans so as to provide two additional railway tracks. The changes will increase the cost of the structure about $900,000.

TESTS OF GRAIN PRESSURE IN DEEP BINS AT BUENOS AIRES, ARGENTINA.

By Eckhardt Lufft,* M. E.

In the design of a large deep-bin grain elevator in the harbor of Buenos Aires, two years ago, the lack of sufficient experimental data on the pressure of grain in bins was strongly felt. At that time (1902) the only published experiments were those of Janssen and those of Prante, which have been repeatedly mentioned in these pages. Since the tests of Janssen were made on model bins of small scale, while those of Prante were made on a full-sized bin, it was thought that for the design of the Buenos Aires elevator the latter should be given more weight. This meant that the surprising result put forward by Prante was to be duly regarded in the computation: Namely, that when the grain was running out of the bin the lateral pressure of the grain against the bin wall was greatly increased, and that with increasing velocity of grain flow the pressure constantly approached the pressure which would be exerted by a fluid of specific gravity equal to that of the grain. Thus, for example, Prante found, for a round bin of 11½ ft. diameter and about 52 ft. height, a maximum pressure of 8.1 lbs. per sq. in.

As the readers of this journal may already know, the tests made subsequent to those of

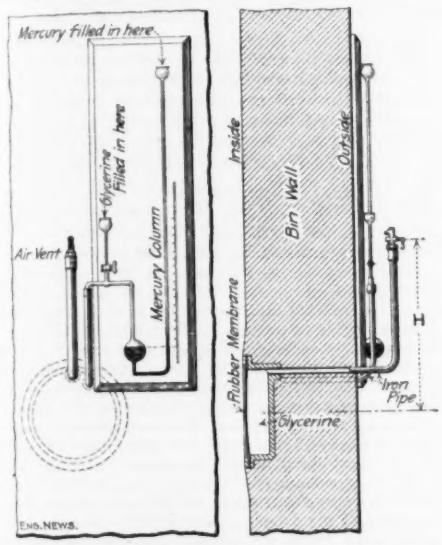


Fig. 1. Pressure Gage Used In Grain Pressure Tests at Buenos Aires, Argentina, and Arrangement with Reference to Bin Wall.

Prante have never shown a confirmation of such remarkable pressures.† Since, however, at the time of the construction no such data were available, it was necessary to use this high pressure in the calculations for the design of the elevator. The whole elevator, of over one million bushels capacity, was therefore designed on this basis.

Even at that time, however, the purpose was entertained to make a thorough series of pressure tests after the completion of the structure. These tests were carried out in the time from February to November, 1903, and their results are summarized in the following.

It was first necessary to construct a suitable pressure gage, avoiding the defects inherent in the piston type of apparatus previously used. The fact that grain pressure has some analogy to fluid pressure led to the design of an apparatus in which the grain pressure is balanced by an opposing column of fluid. As will be seen, the apparatus built is remarkably like that used by Mr. J. A. Jamieson, which he has described in a paper§ written since the Buenos Aires tests were completed. In the design of this apparatus, the leading idea was to replace a small section of the bin wall by a flexible rubber surface, so that the grain pressure could act through this surface upon a counterbalancing column of fluid, as, for example, a mercury column. To this end a design as exhibited in Fig. 1 was developed. The pressure gage comprises a cast-iron body or pressure chamber, open on one side, which side is then covered over by a thin sheet of rubber. This pressure chamber is embedded in the bin wall in such a manner that the surface of the rubber membrane falls in the plane of the bin wall. Care was taken, in putting the membrane in place, that the rubber sheet should not be *stretched* over the mouth of the pressure chamber, but should rather have some slack. As also shown in Fig. 1, two gas pipes pass from the pressure chamber through the bin wall; one of them leads to a U-tube containing a mercury column, while the other serves as air vent during the process of filling the chamber with the liquid used. Glycerine was used at first, though later water was also experimented with. Since the two gas pipes turned off upward from the pressure chamber and were filled with glycerine at the beginning of the test, they served to put the rubber membrane under some initial pressure from the inside. By this means, it was made sure that the rubber surface would be slightly convex toward the inside of the bin. The intention was to avoid any possible concavity of the membrane; for, if the rubber surface were concave, part of the load on it would be carried by the membrane acting as a suspension structure, instead of the entire grain-pressure being transmitted to the fluid. This initial pressure, of course, which required counterbalancing by a certain amount of grain placed in the bin, was taken due account of in the computations; the distance H in Fig. 1 is a measure of this initial pressure.

Some of the tests were made with a pressure-indicating instrument of the ordinary type, in place of the mercury column; this instrument was, of course, carefully calibrated before using.

The size and arrangement of the bins in the Buenos Aires elevator is sufficiently explained, as far as these tests are concerned, by Fig. 2. The bins are circular in ground plan, of two different sizes, respectively 23 ft. 10 ins. and 11 ft. 3 ins. inside diameter. Their depth is 54.8 ft. The bin walls are constructed of concrete, with round iron rods embedded. The inside surfaces of the bin walls have a facing coat of rich cement mortar. Pressure gages, as described, were fitted to four adjacent bins, marked A, B, C and D in Fig. 2, A and C being large bins, while B and D are small bins. The intermediate space enclosed by these four bins is also intended to be used as a grain storage bin, but was not put into service during the period that the tests were made. This left the pressure-measuring apparatus open to thorough inspection at all times.

The large bins (such as A and C) have a capacity, when full, of 19,000 bushels each, while the smaller bins, B and D, have a capacity of 4,250 bushels each. The pressure gage fitted to bin D broke before the tests were begun, so that observations were made only on the three bins, A, B and C, and of these, mainly on bins A and B.

The bins at the time of the tests had not yet been fitted with hopper-shaped outlets, the outlets being simply holes in the flat bottom, as is indicated by Fig. 2. The pressure gages were placed at the distances above the bottom of the bin noted in Fig. 2. An important feature to be noted from Fig. 2 is the position of the gages relative to the outlet openings. In bin A there are four outlets, marked a, b, c and d, respectively, located at different distances from the gage; bin B has only one outlet, which lies almost directly under the point where the pressure gage was located. The position of the outlets has an important bearing upon the observations of pressures.

The serviceableness of the pressure gages is favorably evidenced by the fact that all the curves of observed pressures present the same distinctive character. This is in marked contrast to the results obtained by Prante, whose curves, or rather plots of observations, are extremely erratic. The Buenos Aires tests gave pressure curves in remarkable agreement with those found by Janssen, in 1895, in his tests on model bins. The fear that model bin tests could not be applied to full sized bins is therefore concluded to be groundless, especially as it was later found that the test results corresponded quite closely with those theoretically calculated by Janssen. It will be remembered that Mr. Jamieson came to exactly this same conclusion, and was thereby led to supplement his full-sized bin tests by much more extended tests on small-sized model bins of various kinds.

Of the many pressure curves taken from bin A, a specimen curve is shown in Fig. 3, herewith. It represents the pressures observed while the bin was filling with thoroughly dry wheat weighing 48 lbs. per cu. ft. The date of the test is May 4, 1903. In this elevator the grain is carried by a belt conveyor to the bin, passing through a system of automatic scales of the Chronos make. At intervals of ten or fifteen minutes, simultaneous readings were made on the pressure gage and on the scales, so that the depth of grain corresponding to any particular reading of the gage could be computed. It was assumed in this calculation that the grain had a horizontal flat surface, while in reality the surface was a flat cone.

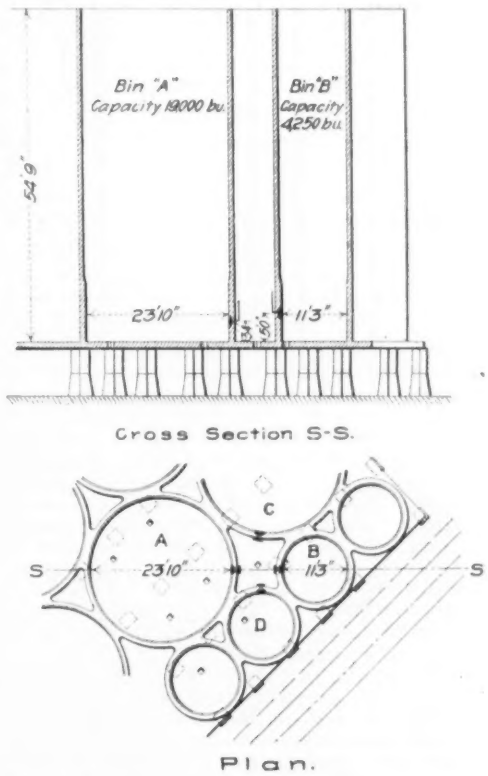


Fig. 2. Part Plan of Buenos Aires Grain Elevator, Showing Location of Pressure Gages.

But this slight inaccuracy is of no influence, except possibly in the neighborhood of the zero point.

Special importance and interest attached to the tests made with bins emptying. But even the first test of this kind gave no evidence whatever of a rise of pressure to several times the initial value, but, on the contrary, showed an actual reduction of pressure. In subsequent tests, it is true, a slight increase of pressure was observed now and then; but in each case this amounted to only a few millimeters of mercury column. In this connection, it was of much moment which of the four outlets of bin A was first opened, and whether the slide was opened slowly or rapidly. For example, if the outlet nearest to the gage was rapidly opened, the behavior of the gage was such as to give the impression that the grain in the neighborhood of the gage flowed out in the first lot, producing a strong decrease of pressure. If the outlet was opened very slowly, or in stages, then it appeared to be more the central and higher portions which formed the flowing stream; and, correspondingly, there was no release of pressure on the membrane of the gage and at times, in fact, a slight pressure-increase.

Fig. 4 shows the characteristic form of all emptying curves. The pressure at which the curve begins is usually very considerably below

*Esslingen bei Stuttgart, Germany.

†See records of very complete experiments on grain pressure in full-size bins, in Engineering News of March 10, 1904 (pp. 236-243), and July 14, 1904 (pp. 32-34).

§"Grain Pressures in Deep Bins," by J. A. Jamieson, Engineering News, March 10, 1904 (pp. 236-243).

the pressure observed for the same depth of grain during the filling. Throughout a large part of the process of emptying the bin, the pressure remains at approximately the same height, or even increases a trifle, and during the last 18 ft. is higher than the pressure for the same depth during bin filling. Only in the last 6 ft. is a very rapid decrease observed.

Fig. 5 shows the filling and emptying curves for corn (maize) in this same bin, that is, bin A. The corn weighed 48.4 lbs. per cu. ft., and was of good quality. The double-stepped form of the pressure line for filling is a result of the fact that the filling was not continued in one uninterrupted process, but was done in three stages, separated

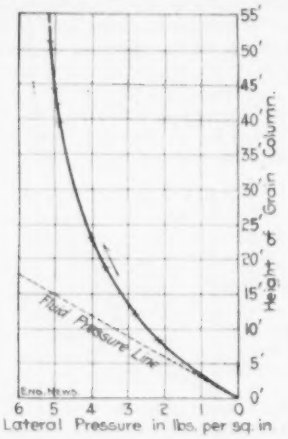


Fig. 3. Wheat, 48 lbs. per cu. ft., Bin Filling.

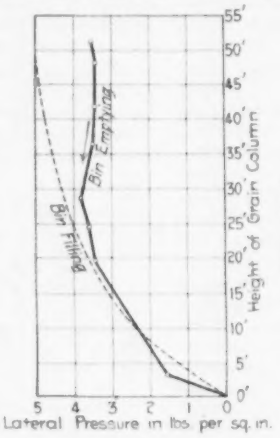


Fig. 4. Wheat, 48 lbs. per cu. ft., Bin Emptying.

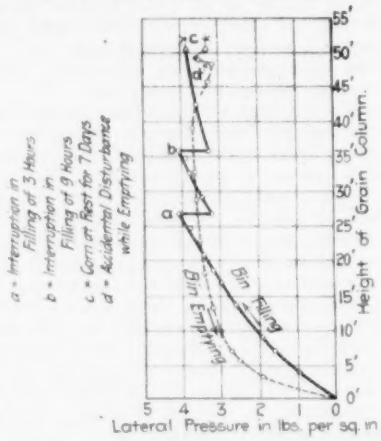

a = Interruption in Filling of 3 Hours
b = Interruption in Filling of 9 Hours
c = Corn at Rest for 7 Days
d = Accidental Disturbance while Emptying
Bin Emptying
Bin Filling
Height of Grain Column.
Lateral Pressure in lbs. per sq. in.

Fig. 5. Corn (Maize), 48.4 lbs. per cu. ft., Bin Filling and Bin Emptying.

FIGS. 3, 4 AND 5. CURVES OF LATERAL PRESSURE IN LARGE BIN.

Circular Bin, 23 ft. 10 ins. diameter, 54.8 ft. deep. Walls of reinforced concrete with facing of rich cement mortar. Bin-bottom flat.

by intervals of several hours, as noted on the diagram (Fig. 5). In this test, and in most other cases, indeed, it was observed that immediately after stopping the process of filling, the pressure decreased, until after several hours—sometimes several days—it reached a practically constant point. This means that the grain immediately after filling has the most similarity to fluid, but loses it in great part, the friction against the bin-wall increasing. This process is twice distinctly observable in the maize curve (Fig. 5), and the drop in pressure at each of these points is seen to be quite considerable.

Although at first sight it seems surprising that the lateral pressure of the grain decreases although the grain is at perfect rest, the matter becomes more comprehensible on the assumption that, after the filling is completed, the individual grains undergo very small changes in position, and thus adjust themselves more closely to the small irregularities of the wall surface, thereby increasing the friction against the wall. The bin-walls, therefore, are gradually required to carry more and more of the grain load, and consequently the downward pressure and the horizontal pressure are necessarily decreased.

This decrease of pressure is observable even during the process of uninterrupted filling, provided the filling is done very slowly. Perhaps this fact may explain the observations reported occasionally in the literature of grain pressures, that the lateral pressure has its maximum value at one-third of the bin height, decreasing from there up and down (see, for example, Engineering News, April 28, 1904, page 404, and Engineering News, July 14, 1904, page 33, Figs. 1 and 3). It is possible that such observations were made with unduly slow filling of the bin.

Since the behavior of the grain in the first period after the opening of the slide is particularly interesting, I give below the record of observations for the maize test, represented by Fig. 5:

Emptying of bin A, November 21, 1903. The bin is full, with the grain 16.6 meters deep. Of the four outlets, the two most distant from the apparatus (c and d, Fig. 2) are used. The mercury column stands at 136 mm. To avoid any sudden drop of the mercury column at the first opening of the slide, which had been previously observed, the slides c and d are opened with the greatest care and very slowly, c being opened first. The result is that the pressure slowly rises to 145 mm. when c is wholly opened, and still further rises to 150 mm. when d is fully opened. At this time the rate of outflow is about 3,500 bushels per hour.

When about 1 m. in depth has flowed out, the mercury column, rising and falling slightly, has reached about 155 mm. Suddenly, through a mistake on the part of the bin-tender, the outlet c is closed and outlet a is opened; immediately the mercury column falls to 128 mm. After the proper condition is again restored, the pressure recovers, reaches its maximum at about 43 ft. height of grain column, maintains this maximum until about 33 ft. height of grain column, and then begins to decrease markedly.

Since the filling and emptying of bin A was not done especially for the purposes of the test, but generally only when it was required in the course of the operation of the elevator, it resulted that the pressure gage remained under the pressure of the filled bin for frequent periods of time. It was observed that the lateral pressure showed small variations even many days after the filling, during which time the contents are in complete rest. This would seem to warrant the conclusion that even after such periods there are small displacements within the mass of grain, although these displacements are doubtless very small and in no case extensive or general.

It was further observed that the same lot of grain, when filled into the same bin two consecutive times, did not necessarily exert the same

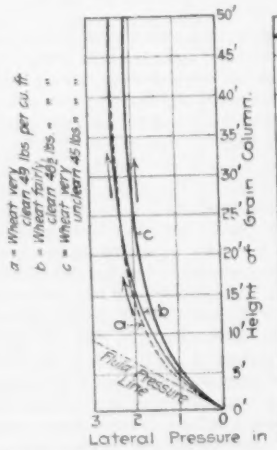

a = Wheat very clean, 49 lbs per cu. ft.
b = Wheat fairly clean, 49½ lbs.
c = Wheat very unclean, 45 lbs.
Fluid Pressure Line
Height of Grain Column.
Lateral Pressure in lbs. per sq. in.

Fig. 6. Comparative Curves for Wheat of Various Grades, Bin Filling.

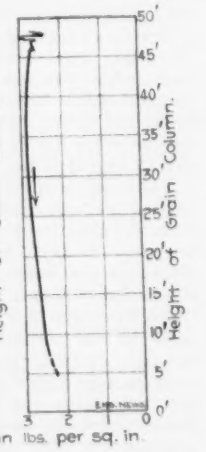


Fig. 7. Wheat, Bin Emptying.

Figs. 6 and 7. Curves of Lateral Pressure In Small Bin.

Circular Bin, 11 ft. 3 ins. diameter, 54 ft. 9 ins. deep. Wall of reinforced concrete with facing of rich cement mortar. Bin-bottom flat.

pressure on the gage, but small differences were observable. In this, doubtless, the speed of filling is of some influence, but very probable, also, local variations in the quality of the grain, particularly when part of the grain near the gage contains more foreign matter than the average of the lot. It is always necessary to remember in dealing with grain, that grain is not an absolutely homogeneous substance, and correspondingly cannot be expected to possess the same friction coefficient throughout its mass. On this account, it may be advisable to increase all observed experimental pressures by about 10%, in order to make sure that the pressure corresponds to the maximum probably occurring in any part of the grain mass. Mr. Jamieson, in his paper printed in Engineering News of March 10 1904, recommended a similar increase, although his purpose was more to make allowance for a possible pressure rise at the beginning of the emptying.

Some observations made on the small bin (bin B) are grouped in Fig. 6, which, although they show small variations between themselves, yet have all the same general character and agree satisfactorily. The pressures are quite materially less than those in bin A, corresponding to the fact that the diameter of bin B is only half that of bin A. The ratio between the pressures is approximately in the ratio of the bin diameters, as the method of computation first given by Janssen postulates.

The pressures in Fig. 6 all are for bin filling. A corresponding emptying curve is given in Fig. 7. In interpreting this curve, it is essential to remember the position of the gage with relation to the outlet opening. The gage is almost precisely vertically above the outlet slide, and, as was distinctly observable during emptying, it was exposed alternately to the pressure of flowing grain and to the pressure of grain at rest. The stream of flowing grain does not appear to have a constant location or direction within the bin at first, but to shift around quite variably; only later in the process of emptying does it have a more constant path. This may be concluded, also, from the record of observations taken for the test represented by Fig. 7, as follows:

Emptying of bin B, November 30, 1903. The slide is opened 9.50 p. m., at first very slightly, which, however, results immediately in a drop of the mercury column, due to the flowing of material in the immediate neighborhood of the gage. The mercury originally stood at 96 mm. Immediately after the initial drop, the column shows violent variation between 80 and 90 mm., then between 90 and 100 mm., and even beyond this. By this time the slide has been about half opened, and the oscillations of the mercury column touch 112 mm. The rate of outflow at this time is about 3,000 bushels per hour. At 10.00 p. m. the mercury column is fairly quiet. The outlet slide is now drawn completely open, which again causes violent oscillation of the column. Momentarily the effect of the flowing grain forces the column up to 120 mm. At 10.05 the oscillations are smaller, and average only 3 to 4 mm. The height of the grain column has fallen about 6 ft. since the beginning of the test. From this point on, the mercury quiets down more and more, and after 6 ft. more have flowed out it falls slowly and steadily.

Many other curves of more or less the same general form were taken from bin B. Indeed, the curves shown in Figs. 3 to 7 are quite representative ones taken from a large group of tests.

It should be remarked that the use of this pressure gage for the measurement of *decreasing* pressures is of somewhat doubtful value, since the yielding of the grain at the point of contact with the rubber membrane has a great influence on the results. This should be borne in mind, for example, in interpreting the curve of Fig. 4. Yet the apparatus gives a very good indication of whether, and what degree of, *pressure increase* occurs during emptying; and this is precisely what the designing engineer requires to know.

The preceding-described tests give, in their essential features, a confirmation of what has been given in Engineering News in its issues of March 10 and July 14, 1904. Since it is very desirable, however, to have further clearness and certainty on the subject of grain pressures in the very important field of elevator construction, it is thought that engineers interested in this class of work will find something of value in this presentation.

A new feature of the Buenos Aires tests is the size of the bin on which they were made (19,000 bushels capacity), which is larger than any grain bin previously tested for pressure. The very satisfactory agreement between the calculated and the observed pressures for a bin of this size, notably extends the range of dimension over which definite knowledge of conditions in elevators exists.

STAYBOLTS, BRACES AND FLAT SURFACES IN BOILERS.*

By R. S. Hale,† M. Am. Soc. M. E.

The problem of the support of flat surfaces arises in the design of the fireboxes of locomotive and upright boilers, in the design of combustion chambers of Scotch marine boilers and in the design of the heads above the tubes in horizontal tubular boilers of all classes.

STAYBOLTS.—The stress on the staybolts is in general a direct pull. In the case of diagonal braces the actual stress may be reduced in figures to an equivalent direct pull by considering the angle between the brace and the plate. In the case of short stays there is a bending action due to differences in expansion of the inside and outside plate which causes special stress which will be considered below.

The maximum working stress permitted in staybolts is as follows:

	Lbs. per sq. in.
United States Rule	6,000
British Board of Trade	9,000
British Lloyds, 1¼-in. diam. or less	8,000
" " over 1½-in. diam	9,000
German Lloyds, 1/7 of tensile strength. For 60,000 lbs. this is	8,500
Bureau Veritas, 1 ÷ 5.75 of lower test limit, then add ⅛-in. for material of 60,000 lbs. strength. For a 1-in. stay this is..	on Net Section,.. 10,400 on Gross Section, 8,300
Hartford Boiler Insurance Co., no official rule but in "The Locomotive" of September, 1893, recommends 7,500 on long stays and in same paper, March, 1892, recommends 4,800 on short stays	7,500 4,800

None of these rules, except the practice of the Hartford Co., take any account of the difference in stress between short and long braces. Some of them allow a greater stress on large braces, as, for instance, Lloyds and Bureau Veritas. Now, in short braces, such as those in locomotive fireboxes, the difference in expansion between the inside and the outside sheet bends the stays and induces severe stresses in addition to the direct pull due to the steam pressure. As a result, such staybolts are frequently found broken close to the outside plate. Further, as is well known, excessive stress and strain makes the metal more liable to corrosion, and these short bolts are frequently found corroded and wasted.

In boilers with long braces such as the ordinary horizontal tubular boilers we very seldom find any corrosion. However, an allowance for corrosion would appear excellent practice, even if corrosion appear but seldom, and the rule of the Bureau Veritas, by which the stress is computed on the net area that will remain after ⅛-in. (1/16-in. on each side) has been wasted, is an excellent one. For long braces where there is no bending action, say braces of 2 ft. and over, there would appear to be no reason why the stress should not be as great as that allowed on similar metal in boiler plates. In boiler plates a stress of 12,000 or more is allowed between rivet holes, and from 7,000 to 11,000 in the body of the plate. It would, therefore, appear that we can safely take 12,000 lbs. per sq. in. for long steel braces, or 10,000 for iron. While this allows considerably more pressure than has been usual in some cases, the fact that these long braces give but little trouble would seem to warrant increasing the pressure. The allowance of ⅛-in. for future corrosion makes this agree better with current practice than is apparent at first sight. Thus, with a 1-in. brace, 12,000 lbs. per sq. in. on the net section, which is ⅞-in. diameter, is 9,200 lbs. per sq. in. on the gross section, or but little more than is now usual. For large braces the proposed rule will allow higher pressure than is now customary, but our experience with such cases as have come to our notice indicates that it will be amply safe.

On short braces the working stress due to tension alone should be less in order to leave a margin for the bending stress. These braces are usually iron, and if we make the permissible stress 9,000 on the net section after subtracting 1/16-in. on all sides, on iron braces less than 24 ins. long, 8,000 if less than 12 ins. long, 7,000 if less than 6 ins. long, and 5,000 if less than 4 ins. long, we shall get results that will be in better accord with present good practice and experience than any of the rules stated above. The difference will, at least, take partial care of the stresses due to bending.

The variations above suggested according to length of braces are not based on any theory, but are chosen so that for very short braces the stress shall be about that which locomotive boilermakers have found good practice, with stresses on braces of intermediate lengths something in proportion.

In the case of the circular fireboxes of upright boilers it must be remembered that the strength of the furnace as a flue diminishes the stress on the staybolts.

STRENGTH OF PLATE.—We may now consider the strength of the plate itself, and this obviously depends on the distance between stays and the thickness of the plate. It also depends somewhat on the diameter of the stay, since we can easily imagine an extreme case, in which the stays were so large as to diminish appreciably the area of plate to be supported. It is obvious, however, that for any given method of attaching the stay to the plate a change in the diameter of the stay will affect the stresses by but a very small amount; hence it will be correct to neglect this factor in determining the thickness of the plate for any stated method of attachment and distance between stays. The method of attachment of course, affects the safe working pressures.

The theoretical stress, independent of method of attachment, or rather for stays of infinite strength attached at points, has been found by Grashof (Unwin, "Machine Design") to be as follows:

$$f = \text{maximum stress} = \frac{2\,p^2}{9\,t^2}\,P,$$

where p = pitch, t = thickness of plate, P = steam pressure; all in pounds and inches.

Since the stress on the bolt itself is given by the formula:

$$f = P\,\frac{4\,p^2}{\pi\,d^2},\ d \text{ being the diameter of the bolt,}$$

it is interesting to note that for equal stress in bolt and plate the bolt should be 2.4 times the thickness of the plate, whatever the pitch, for the case covered by the formula.

The stress on the plate is stated by D. K. Clark to be determined as follows: Steam pressure at elastic limit of plate equals $5{,}700 \times \frac{t}{p}$, p in this case being distance between bolts, not between centers. Although Clark states this to be the elastic strength, yet it appears to be more probable that it is some fraction of Clark's idea of the ultimate strength. It would probably be as wrong to depend on Clark in such a case as it would be to use his theories as to strength of beams in designing bridges, instead of using the formulæ based on the elastic theory, such as the formulæ used by all the best engineers in designing every large bridge or steel frame building.

The rules used by the various insurance and similar bureaus are as follows:

United States, $P = C\,\frac{t^2}{p^2}$; C = 112 for steel plates 7/16-in. or less.

British Lloyds, $P = C\,\frac{t^2}{p^2}$; C = 90 for screw stays 7/16-in. and less.

German Lloyds, $P = C\,\frac{t^2}{p^2}$;

Board of Trade, $P = C\,\frac{(t+1)^2}{p^2-6}$; C = 66.

Bureau Veritas, $P = \frac{(t-1)^2}{2\,p}\,\frac{T}{C}$;

T = tensile strength taken at 25.8 tons or 60,000 pounds in following computations.

C = .055 and less.

Hartford Boiler Insurance Co., in "Locomotive" of March, 1892, page 38, advocates D. K. Clark's rule with a factor of safety of 3, based on the elastic strength. His rule is:

$$P = \frac{5{,}700\,t}{p},\ t \text{ being thickness in inches, p is the net pitch, i. e., distance between staybolts and not between centers.}$$

The figures given in the tables following take p as the distance between centers in all cases. If it was worth while to take account of the difference the figures could be corrected accordingly for Clark's formula.

The constants above given are considerably increased for other methods of attaching stays to plates than merely screwing in and riveting over.

In Table I. herewith are given the permissible pressures by these rules for various thickness of plates and for pitches from 4 to 11 3/16 ins.

The double figures given for the Board of Trade in the first two lines of Table I. are the figures from their rule and the figures from Trail's Board of Trade Tables for pitches under 6 ins., which tables, it is understood, supersede the rules for these small pitches.

It should, of course, be understood that probably none of the rules are intended for extreme cases. For pressure under 30 lbs. various other considerations would, of course, enter; for pressures above 250 lbs., temperature changes in the plate would very likely make the rules inapplicable. In other words, none of these rules are intended for extreme cases, and for ordinary working conditions it appears they give results that do not differ widely from each other.

Such being the case, the simplest formula is probably the best. Further, there should be a decided preference for formulæ that agree with the theoretic formulæ rather than for empirical formulæ. Of course, an empiric formula may represent the results of a few experiments better than a theoretic one, but unless the experiments are very numerous and very accurate the chances are that the differences between the empiric and theoretic formulæ are due to errors of experiment.

In this connection it may be noted that such experiments as have been made, notably those of Fairbairn, Clark, Wilson, Greig, Eyeth and the Board of Trade (see Stromeyer, p. 140, for a list of these) are not complete enough and apparently are not accurate enough to furnish any rule. This is only what is to be expected since experiments on flat plates, if the plates are tested to breaking, or even only to bulging, deal with pressures and strains far in excess of working conditions and must deal with the metal in a more or less plastic state. Experiments to determine the actual working stress in flat plates under ordinary conditions would have to be very refined experiments in which the stresses were inferred from the measurement of infinitesimal deflections, and these experiments have not been made. As stated above, the case is very similar to that of iron beams, in which the working stresses have to be computed from the elastic theory, since experiments by testing beams to destruction give results which we know are not to be relied upon in designing.

Hence, it follows that the theoretic form used by the United States, German and British Lloyds, etc., is the best, and that Working pressure = Constant $\times \frac{t^2}{p^2}$ is the form to be adopted. In regard to choice of constants it is interesting to note that on the whole the United States rule gives results intermediate between the British Board of Trade and the Bureau Veritas, although considerably higher than the British Lloyds.

In order to see if these results were borne out by experience I have made up a list of the most recent cases in which our inspectors have found plates bulged between staybolts, Table II., herewith. It is clear that if weakness caused these bulges, all the rules give much too high pressures, but it is more probable that these bulges are most of them due to overheating, just as the bulges in the furnaces of internally fired boilers, or the bottom plates of horizontal return tubular boilers, and that they are not due to weakness of design. In other words, they are due to abnormal conditions, and are to be prevented by care in the operation of the boiler rather than by change in the design.

The proper constant, therefore, is somewhere between 90 and 120, and since failure will not cause serious accident it would seem wise to use 115 in determining the limiting safe pressure, while 100 will give good results when designing a new boiler for economically long life.

The United States and Lloyds permit a slightly higher constant for thick plates than for thin, and the Bureau Veritas rule has this effect. Lloyd's rule and Clark's have

*A paper presented before the American Society of Mechanical Engineers at New York, N. Y., Dec., 1904.

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TABLE I. Allowable Working Pressures on Flat Surfaces in Boilers, lbs. per sq. in. Steel Plates. Screw Staybolts Riveted.

Pitch of Staybolts, c. to c.	Thickness of Plate, In.	British Board of Trade.	United States Rule.	Bureau Veritas.	British Lloyds.	D. K. Clark.
4 ins.	¼	123 / 165	112	90	90	107
	5/16	176 / 237	175	160	141	149
	⅜	323	252	250	203	178
	7/16	422	343	360	276	208
6 ins.	¼	55	50	40	40	70
	5/16	79	78	71	62	90
	⅜	108	112	111	90	120
	7/16	178	214	218	177	158
	½	266	334	360	278	198
	9/16	372	480	538	400	238
8 ins.	¼	28	28	22	23	59
	5/16	56	63	63	51	89
	⅜	92	120	122	100	109
	7/16	138	188	202	156	148
	½	193	270	302	225	178
11 1/16 ins.	¼	18	14	11	11	12
	5/16	26	31	31	25	63
	⅜	44	60	61	50	84
	7/16	65	94	102	78	105
	½	91	135	151	112	126
	9/16	121	185	212	153	147

TABLE II. Recent Cases of Bulges Between Staybolts Found by Mutual Boiler Insurance Company Inspectors.

Working pressure. Lbs. per sq. in.	Pitch of stays. Inches.	Thickness of plate. Inches.	Allowable pressure by U. S. rule.
65	5	⅝	112
80	7⅛	1¼	32*
75	7	⅞	57*
85	4	½	173
75	8	⅝	29*
80	5½	⅝	132
100	4	⅝	250
75	4	½	173
70	4	½	173
80	8 x 7	¾	32*
75	4	½	173
60	7 x 7½	⅞	50*
100	4½ x 5	⅝	180
120	4	⅝	250**
80	6 x 5⅛	¾	120
115	6	⅝	112**
120	6	⅝	112**
100	4⅜	⅝	400
60	6½	⅜	98
60	4⅜ x 5	⅞	123

* Small circular firebox. ** Large circular firebox.

just the reverse effect. I cannot see anything either in our experience or the experiments that warrants allowing proportionate greater pressure on thick plates than called for by Grashof's formulæ, except so far as may be desired for corrosion in special cases, where it is thought corrosion should be specially provided for.

For braces attached by nuts or crowfoot braces attached by rivet, it is obvious that a higher pressure can be allowed. Lloyd allows about 20% more for nuts, United States about 20% more, Board of Trade about 25% more. A constant of 140 which would agree with the margin in the other rules, is good practice.

For horizontal return tubular boilers the braces, when small diagonal braces are used, are attached to the heads by crow-feet and rivets. For this case a constant of 140 appears to give results in accordance with good practice.

For the cases where the stays or braces are in the steam space, with fire or hot gases on the other side so that the plate and ends of the braces are exposed to overheating, the British Board of Trade diminishes its constant and the allowable pressure by some 40%. The other rules take no account of such cases, but apparently allow full pressure. Such a flat surface with steam on one side could not safely be exposed to the full heat of the furnace at any pressure and yet be safe. On the other hand, if exposed to comparatively cool gases it may be safe as if it had water on one side, instead of steam, but was exposed to the full heat of the furnace.

It follows, therefore, that no general rule can be laid down, but the constant for stays in the steam space, when the plate is exposed to the products of the combustion on the other side, may have to be reduced according to the particular case.

The foreign rules allow quite an excess of pressure for various washers, etc. As Stromeyer has shown, however, thicker plates are cheaper than such washers, and the use of channels or angles as in United States practice seems also to be superior. For such construction a constant of something like 200 to 250 may probably be taken, but the exact amount would so depend on the washers, the two pitches, on the shape and dimensions of the channels, on the riveting, etc., so that no rule could be laid down.

In the above discussion it has been assumed that the stays are all pitched in squares. If they are not, the British Board of Trade uses the square root of the surface and the Bureau Veritas the square root of half the sum of the squares, for the pitch. In general, it seems to be assumed that if the pitches differ only slightly an intermediate figure as in these rules may be taken, while if they differ largely the case must be specially considered. The rule of the British Board of Trade for using the square root of surface, i. e., of the product of the two pitches if they differ slightly, is simple and probably as correct as any, within the limit of say 20% variation.

SUMMARY.

STAYS.—Comparison of the various rules for working stress on stays and braces shows a general neglect of the difference between long and short stays. For long steel stays, subtracting ⅛-in. from the diameter, and then allowing 12,000 lbs. per sq. in. on net section remaining, gives results which apparently will be better than any of the present rules. For iron stays probably 10,000 should be used. For short stays, which are chiefly iron, where bending action comes in, empiric rules reducing stress as length of stay decreases may be used. Our knowledge of the bending stress is not sufficient to warrant the use of a more theoretic formula.

PLATES.—Comparison of the working pressures for pitch of stays and thickness of flat plates shows that the complicated formulæ of some of the rules do not give as good results as the simpler formula $P = C\frac{t^2}{p^2}$, C being taken as 100 to 115 for riveted stays, 140 for stays nutted or crowfoot stays riveted on, and a higher value up to 200 or 250 for the use of washers or channels or angle bars riveted on.

If the pitches differ by less than 20%, use the surface instead of p^2. If the pitches differ by more than 20% it is a special case. Special cases and unusual construction must always receive special consideration.

The above constants give results indicating the probable safe pressure for a year or so, until the next examination. In designing a boiler for a long life the constants should be reduced by some 20% or so, just as a factor of safety of 4 can sometimes be used temporarily for the shell of a new boiler, while 5 should be used in designing a boiler to be run for a number of years without reduction of pressure.

BURSTING TESTS OF FOUR-FOOT FLY-WHEELS.*

By Charles H. Benjamin,† M. Am. Soc. M. E.

Experiments on bursting of fly-wheels made hitherto by the writer and described in former papers‡ have been confined to the testing of wheels whose diameters were 2 ft. and less. The first wheels experimented upon were only 15 ins. in diameter and could be regarded as models, nothing more. Enough was learned from these tests to make further investigation desirable, and in succeeding years wheels 24 ins. in diameter, of various types of construction and of various materials, cast-iron, steel and wood, were tested to destruction. The interest taken in

Fig. 1. External View.

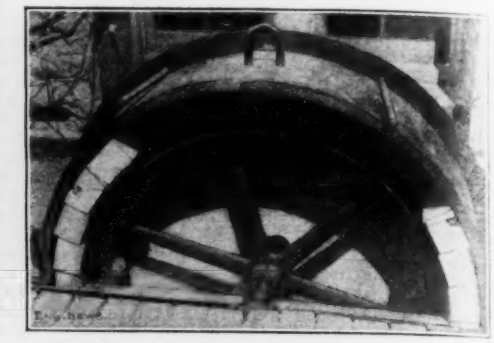


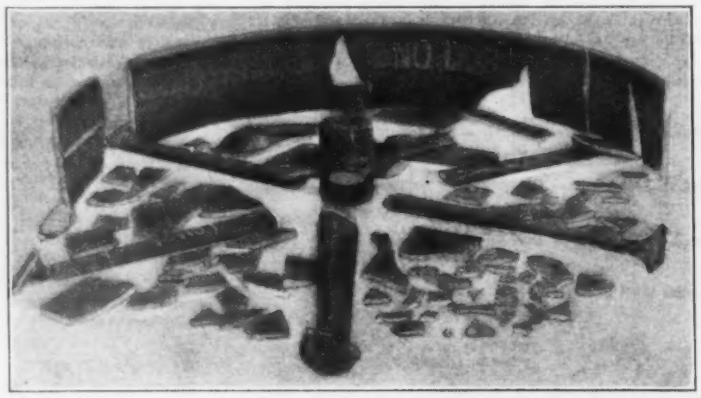
Fig. 2. One Side Plate Removed, Test Wheel I. in Position.

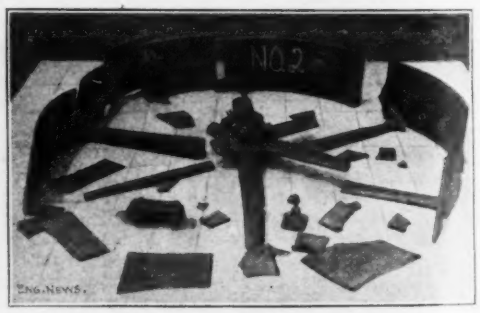
FIGS. 1 AND 2. STEEL CASING FOR BURSTING TESTS OF 4-FT. FLYWHEELS.

these experiments seemed to warrant carrying them further on a larger scale, such as would correspond with sizes actually in use.

Four feet was selected as a limiting diameter and a cylindrical steel casing was built having an internal diameter of 5 ft. Figs. 1 and 2 show the exterior and interior appearance of the casing when completed. The rim or shell was made of steel 1¼ ins. thick, having a tensile strength of about 65,000 lbs. per sq. in. The upper and lower halves of the rim were flanged at the junction and bolted together by 1-in. steel bolts. The sides were of steel ⅝-in. thick, dowelled to the rim and secured by through bolts outside and inside the rim as may be seen from the illustrations. It was not deemed safe to conduct these experiments inside a building, and subsequent developments proved that it would not have been safe, for the building at least. The casing was therefore located just outside the building where the tests were to be made, in a pit or excavation lined with brick, as is shown in Fig. 1. The flanges of the lower half rested on brick piers and were bolted in place. The entire upper half of the casing could be hoisted up, giving access to the interior for setting or removing the wheels. The shaft carrying the wheel to be tested turned in bearings bolted to angle irons on the lower halves of the side plates, and was connected to the driving mechanism just inside the building by a flexible sleeve coupling. After the wheel was in place the casing was lined with wooden blocks to absorb the momentum of the flying fragments, as illustrated in Fig. 2. Instead of using a steam turbine as in former experiments, the fly-wheel shaft was speeded up by means of a Reeves variable speed countershaft interposed between the line-shaft and the driving-shaft.

The first wheel to be experimented on was a well-proportioned cast-iron pulley, such as is used on shafting for transmitting power. This pulley No. 1 is shown in position inside the casing in Fig. 2. It was 48 ins. in diameter, had six arms and weighed 194 lbs. The rim was whole and was 8½ ins. wide and about ⅝-in. thick, finished on the outside. The arms were elliptical in section, 3⅛ ins. by 1 1/16 ins. at the hub, and 2 ins. by ¾-in. at the rim. On the whole the wheel was well designed and showed no signs of shrinkage strains. It had, however, been balanced in the customary manner by riveting a cast-iron washer inside the rim at the lighter side and this proved its undoing. The combination of a light place in the rim, a rivet hole and a heavy mass of cast-iron, is enough to wreck any wheel. As shown in the cut, it was necessary to still further weight this side by winding lead wire around the arm just inside the rim.





FIGS. 3 AND 4. TEST WHEELS I. AND II. AFTER BURSTING.

As has been shown by previous experiments on whole-rim wheels of cast-iron, a bursting speed of 400 ft. per sec. may reasonably be expected. The circumference of a 4-ft. wheel being about 12½ ft., such a wheel should burst at about 32 revolutions per second, or 1,920 r. p. m. The pulley in question burst at 1,100 r. p. m., as recorded by a tachometer connected to the driving-shaft.

The appearance of the wheel after breaking is shown in Fig. 3. The balance weight weighed 3½ lbs. and its center was approximately 23 ins. from the axis of rotation. At 1,100 r. p. m. the centrifugal force of the balance weight alone would be 2,760 lbs. Add this radial pressure at a weak point between the arms to that due to the weight of the rim itself, and the low bursting speed is easily accounted for.

The linear speed of the rim at rupture was 230 ft. per sec. As 100 ft. per sec. is considered the limit for belt speed, this pulley would have a working factor of safety of $(2.3)^2$ or 5.3. But suppose the rim had been a little thinner and consequently a bigger weight had been put on with a larger rivet?

Wheel No. 2 is shown after rupture in Fig. 4. It was a cast-iron pulley of the same general style and dimensions as No. 1, but with a split hub and rim, as may be seen from the cut. The balance-weight was present here as in the former case, but was obliged to yield the palm to its rival, the flanged joint.

The wheel had been cast in one piece, as is usual in such cases, with cavities cored at the joints of rim and hub. After finishing it had been broken apart by wedges, making a fracture joint. The flanges, being located midway between the arms and bolted at some little distance inside the rim, were in the worst possible position to withstand the bending action due to centrifugal force, and their own weight only aggravated the difficulty. The flanges shown in the foreground of the illustration weighed with their bolts 7½ lbs.

This wheel burst at less than 700 r. p. m., the tachometer not recording below this speed. The writer believes the speed to have been about 600 r. p. m. At this speed the centrifugal force of the flanges on one side would have been 1,680 lbs. At 600 r. p. m. the linear speed of rim would be only 125 ft. per sec. At the very common belt speed of 4,500 ft. per min. the factor of safety would have but 2.8, which is altogether too low, considering the nature of the material and the shocks to which a pulley

*A paper presented before the American Society of Mechanical Engineers at New York, N. Y., December, 1904.

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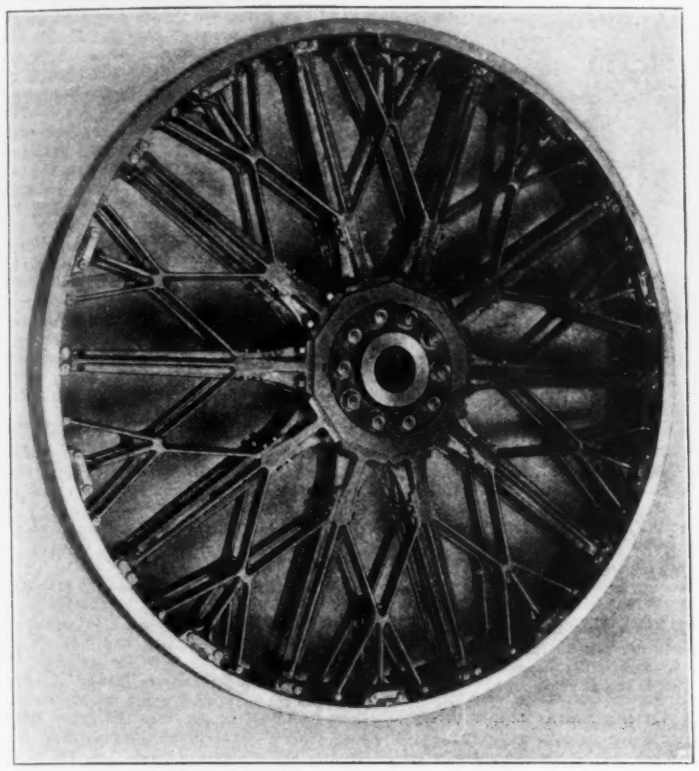
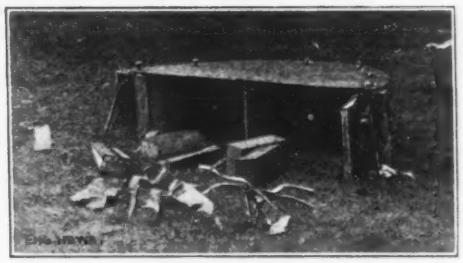
‡See Engineering News, Dec. 1, 1898, p. 349, and Dec. 12, 1901, p. 462.

may be exposed. There is one instance on record of the wrecking of an engine by the breaking of a generator pulley, which had a heavy balance weight inside the rim.

It was reserved for Wheel No. 3 to develop the most dramatic series of incidents of any yet experimented upon, big or little. Fig. 5 is from a photograph of this wheel taken just before setting in the case. The wheel measured 49 ins. in external diameter and weighed about 900 lbs. The rim was 6¾ ins. wide and 1⅛ ins. thick, and was built of ten segments, the material being cast-steel. Each joint was secured by three prisoners of an I-section





FIGS. 5 TO 7. TEST WHEEL III. BEFORE AND AFTER BURSTING.

on the outside face, by link prisoners on each edge, and by a dovetailed bronze clamp on the inside fitting over lugs on the rim. The arms were of phosphor bronze, twenty in number, ten on each side and were a cross in section. These arms came midway between the rim joints and were bolted to plane faces on the polygonal hub.

As shown in the cut the rim was further reinforced by a system of diagonal bracing, each section of the rim being supported at five points on each side, in such a way as to relieve it almost entirely from bending. The braces like the arms were of phosphor bronze, and all bolts and connecting links of steel.

This wheel was designed by a Baltimore firm as a model of a proposed 30-ft. fly-wheel.

On account of the excessive air resistance it was found necessary to enclose the wheel at the sides between sheet-metal disks before any great speed could be attained. Even then repeated trials failed to reach a speed of more than 800 or 900 r. p. m. on account of the great inertia of the wheel and the consequent slipping of belts.

By putting on more and wider belts, by a liberal use of Cling Surface and with the aid of a 7½-HP. electric motor belted on in parallel, it was found possible to get a speed of 1,650 r. p. m. After the wheel had been run at this speed it was stopped and examined. The inspection showed fracture of several of the I-shaped prisoners on the outer surface of the joints and a slight opening of the joints themselves, to the extent of perhaps .01 to .02-in.

On June 2, 1903, the casing was closed for the last time and the combination of driving mechanisms set to work. The observers were all well protected by the thick piers of the building, while other spectators were kept at a safe distance and well away from the plane of rotation. Two of the observers watched the pointer of the tachometer through opera glasses, another kept the time, while a fourth manipulated the driving levers. As the hand of the speed counter reached and slowly passed the 1,600 mark, the feeling of suspense on the part of those watching reached the acute stage. The pointer crept slowly on and as it quivered on the mark of 1,775, there was a sudden crash, a sound of rending and tearing, and the writer saw the countershaft inside writhing on the floor like a wounded snake. On stepping outside he was saluted by a shower of falling splinters and fine debris, and was surprised—putting it mildly—to note the disappearance of the greater part of casing and wheel.

Fig. 6 is from a photograph taken immediately after the explosion and shows the completeness of the wreck. The steel rim of the casing was broken off short 6 ins. below one of the flanges, and the entire upper half, weighing half a ton, was projected about 75 ft. into the air and landed some hundred feet away on the campus. See Fig. 7. On its way up it carried away part of the cornice of the building, and this collision was probably what caused it to deviate so much from a vertical path. The hub and main spokes of the wheel remained nearly in situ, but parts of the rim were found 200 ft. away, while one large fragment landed on the roof of the building.

This sudden failure of the rim casing was unexpected, as it had been thought the flange bolts were the parts which would give way first. The tensile strength of the casing at the point of fracture was about 1,200,000 lbs., or about four times the strength of the wheel rim at a solid section. Examination of the break in the casing showed a clean, bright fracture, with almost no imperfections.

The failure of the wheel itself was due to a gradual opening of the joints occasioned by the fracture of the outside prisoners, and to flaws in the bronze castings of the arms near their junction with the rim. On putting the pieces of the wheel together in their original order it was easy to locate the joint which first gave way, on account of the symmetry of the breaks either side of a diameter through this point. It is but fair to the builders of the wheel to say that the fractures showed uniformity of

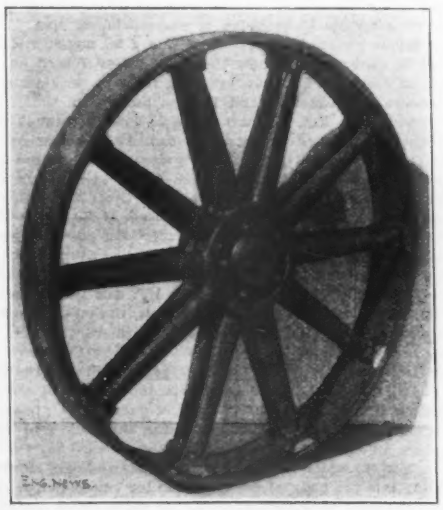


Fig. 8. Cast Steel Flywheel, Not Yet Tested.

strength and of workmanship, since there was hardly a member or a joint which did not fail in one part or another of the wheel.

A speed of 1,775 r. p. m. means a linear speed of rim of 22,300 ft. per min. or 372 ft. per sec. This is not as great as the probable speed of a solid cast-iron rim of good design, but it is greater than the speed of any sectional or jointed rim which has been tested. The tensile stress due to the centrifugal force at this speed is 13,800 lbs. per sq. in. This shows that the joints were much weaker than the solid rim.

On the whole the test of this particular wheel was disappointing, since its strength was not sufficient to repay one for the expense of the design.

It is interesting to compare the kinetic energy of the rim of the wheel at the recorded speed with the work of destruction. Assuming the rim with its lugs, flanges, etc., to weigh 300 lbs., which is a reasonable estimate, the kinetic energy at a speed of 372 ft per sec. would be 645,000 ft. lbs. Further assuming that none of the energy was dissipated in heat, and that the combined mass of wheel and casing projected into the air weighed 1,500 lbs., we find the height of projection to be 430 ft. It is good cause for congratulation that four-fifths of the energy *was* dissipated.

Fig. 8 illustrates a model wheel of cast-steel which has not yet been tested.

The apparatus for the experiments above described was designed and put in position by Messrs. Moulton and Wachalofsky, members of the class of 1903, Case School of Applied Science, and the tests on wheels Nos. 1 and 2 were made by them. For experiments on the last wheel credit should be given to Mr. Geo. E. Daniels, instructor in mechanical engineering, whose patience and ingenuity overcame all the obstacles to obtaining high speed with so heavy a wheel.

The experiments which have just been decided make it clear that more than ordinary precautions must be taken to insure safety. The method adopted by an engineer in Germany for testing emery wheels, seems to the writer well adapted for this purpose. It consists in mounting the wheel to be tested on the lower end of a vertical shaft and sinking the apparatus in a hole in the ground.

The writer hopes to be able to make some experiments on large wheels during the coming year. A pit about 5 ft. in diameter by 3 to 4 ft. deep will be excavated in a gravelly soil, sheet piling being used to enclose the sides. The wheel will be fastened to the lower end of a vertical shaft, running on specially designed thrust bearings and driven by a friction speed controller at the top. A steam turbine will be used as a motive power since this is easier to regulate and less susceptible to injury than the electric motor. Acting on a recent suggestion the writer also hopes to test grindstones and emery wheels in a similar manner.

AN INDICATING STEAM METER.*

By C. E. Sargent,† M. Am. Soc. M. E.

The need of a steam meter has been so great that several devices have been designed for the purpose, but on account of the changing conditions of the product with which we have to deal, only partial success has been attained. (References: U. S. Patent 729511; U. S. Patent

*A paper read before the American Society of Mechanical Engineers, at New York, N. Y., Dec., 1904.

†Sargent Engineering Co., First National Bank Bldg., Chicago, Ill.

481287; "Transactions," A. S. M. E., 1903; The St. John Meter, New York City.)

If we were dealing with a permanent gas of a practically uniform pressure and temperature such as the illuminating gas used for heat and light, then the metering of steam would be a simple problem, but steam is not a perfect gas and usually varies in pressure and temperature many pounds and degrees, and contains more or less water depending on the distance from the boiler, and the efficiency of the insulation of the radiating surfaces. As the steam pressure in various plants varies from below atmospheric pressure when used for heating to as high as

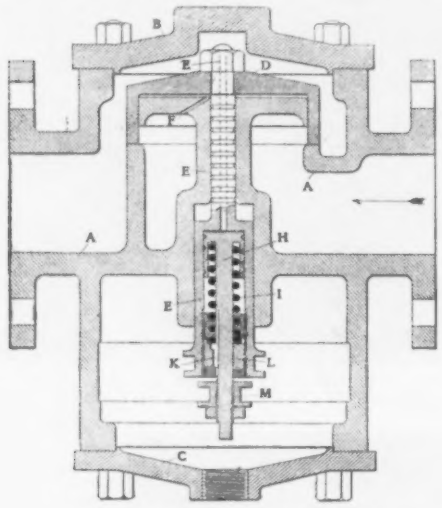


Fig. 1. Longitudinal Section.

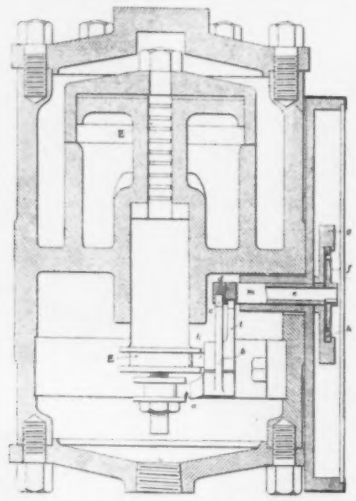


Fig. 2. Transverse Section.

FIGS. 1 AND 2. LONGITUDINAL AND TRANSVERSE SECTIONS OF SARGENT INDICATING STEAM-METER.

200 lbs. per sq. in. where used for power in multiple cylinder engines and steam turbines, meters with considerable range are required, no matter where or for what purpose they are to be used. To design a meter to operate successfully under these varying conditions has been the aim of the writer, and the device herein described is believed to overcome many of the difficulties which have heretofore been obstacles to success.

If there is a constant difference between the pressures each side of a certain opening, the amount of steam flowing through that opening will depend on the area and the density of the steam which varies with the pressure. If the initial pressure and the difference in pressures remain constant, then the weight of steam flowing through will depend on the area of the opening; if the opening is constant, the weight of steam flowing through will vary with the pressure and the difference of pressure on either side of the opening.

If the difference in pressure between two tanks is 1 lb. per sq. in. and the initial pressure varies from 50 to 100 lbs. twice as much steam will flow through a certain opening with 100 lb. as would flow through with 50 lbs. pressure. In the meter under consideration, which is designed for steam pressures of 50 to 100 lbs. a drop of 2% is thought advisable, and the areas are proportioned accordingly. When steam is flowing through, the opening will adjust itself, so that the difference of pressure is always a percentage of the pressure on the inlet side. Any tendency of the pressure to equalize will immediately close the valve, and by thus throttling the passage, reduce the outlet pressure below the inlet pressure as designed. Any tendency for the outlet pressure to reduce more than 2% below the inlet pressure will raise the valve and increase the area of the steam passage. The main valve stem will stand between the position of the full opening or the complete closure of the valve, depending on the amount of steam passing through, and the position of this valve stem determines the movement of an indicating finger around the center of a dial through mechanism hereafter described.

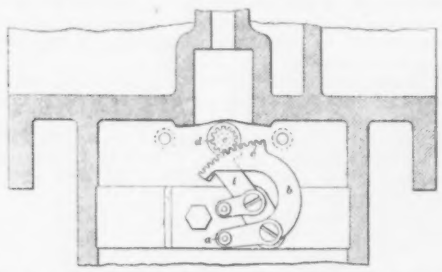


Fig. 3. Part Longitudinal Section of Sargent Steam-Meter, Looking Toward Back of Dial, Showing Indicating Levers.

If the steam always had the same density, that is, if a certain volume always had a certain weight, no further indicating apparatus would be necessary; but as the weight per volume varies with the pressure, the same quantity of steam under double the pressure will flow through one-half the area for the same length of time; also if the difference in pressure across the opening increases with the absolute pressure still more steam will flow through the opening.

On the assumption, then, that pressure times volume equals a constant ($PV = C$) which is near enough for practical purposes, we can determine the amount of steam passing from one receptacle to another if we know the initial pressure and the difference in pressure in the two receptacles, by determining the area of the opening through which the steam flows. This is the principle upon which this meter is based.

Meters having an adjustable opening through which the steam flows have been made, and with a constant pressure they record fairly accurately the pounds of steam passing through them. But with a variable pressure, from the nature of the device, the indication would be inaccurate. Again, in any steam pipe in which the steam is not superheated, there is more or less condensation, which as the demand for steam is suddenly increased, is carried along in the shape of slugs or charges of water, which, travelling at the rate of 100 ft. or more per second, will seriously impair the accuracy of a meter susceptible to derangement by impact. While any steam meter should have a separator between it and the boiler, water can in no way affect the mechanism of the meter herein described, as all moving parts are protected from derangement caused by the inertia of water passing through the openings.

The meter, shown in Figs. 1 to 4 herewith, is a flanged and faced fitting and can be inserted in the steam pipe as an ordinary globe valve of corresponding size. The particular meter shown in Fig. 4 is a 2-in. meter, and its dial is calibrated to show the horse-power (based on 30 lbs. of steam per HP.-hour) passing through, with a steam pressure of between 50 and 100 lbs. per sq. in.

Referring to Fig. 4, if no steam is flowing through the meter, the pointer will indicate zero horse-power as in the figure, but will indicate the pressure if it ranges between 50 and 100 lbs. As the end of the pointer will not begin to move towards the center of the dial until the pressure reaches 50 lbs., it will stand at 50 lbs. when there is no pressure in the meter. If the pressure were maintained exactly at 50 lbs., and 150 lbs. avoirdupois of steam passed through per hour (5 HP. at 30 lbs. of steam) then the pointer would stand at 5 HP. and 50 lbs. pressure. If 40 HP. were passing through, the pointer would so indicate, and if the pressure were raised from 50 to 100 lbs. the end of the pointer would follow the curve of 40 HP. from the 50 to the 100 pressure limit. In like manner the pointer would indicate the weight of steam passing through, no matter how the quantity of pressure varies, provided it remained within the limits of the machine.

In Fig. 1, which shows the steam passage and moving parts, A is the body of meter, B the top cover, and C the bottom cover; D is the self-adjusting valve which remains seated when no steam is passing through the meter, and which is held in place by and fastened to the valve stem E which works in two diameters in the body A. The bottom cover C is tapped for ¾-in. pipe which connects the meter to the atmosphere or sewer.

The action of the meter is as follows: Steam is admitted on the side of the arrow and surrounds the valve stem guide; as soon as pressure accumulates it passes through the small hole F, and raises the self-adjusting valve D, allowing the steam to pass to the outside and top of the valve. As the bottom end of the stem E is open to the atmosphere, the pressure on top of the valve D tends to close same by an amount of pressure equal to the pressure in the meter multiplied by the area of the valve seat immediately below the valve. As the pressure under the valve is always tending to open same, and the pressure on the stem is always tending to close same, there will be a difference in pressure between the inlet and outlet of the meter corresponding to the difference in area of top and bottom of the valve. As these areas are so designed that the ratio is about 50 to 49, the pressure of steam on the discharge side of the meter will be 2% less than on the admission side with any pressure carried. If 100 lbs. pressure is carried on the boiler side of meter 98 lbs. pressure will be delivered on the engine side, and if the admission pressure is only 50 lbs. the discharge pressure will be 49 lbs.

The provision for change of pressure in the steam passing through the meter is as follows: Referring to Fig. 1, the pressure of steam above the valve D, and on the outlet side of the meter, may pass through the hollow valve stem E, and act on the piston H, compressing same, and the spring I, which in the present case is of such a tension that 50 lbs. pressure per sq. in. is necessary to overcome the statical conditions of same, and 100 lbs. per sq. in. is sufficient to compress it to its full limit. The movement of this piston H is transmitted to the roller A, Figs. 2 and 3, which through the bell crank b, the segment c, the pinion d, the shaft e, the large pinion f (Figs. 2 and 4), and the rack h, transmits the movement of the end of the pointer to and from the center of the dial, showing the steam pressure per sq. in. on the meter by moving the pointer radially in or out.

The position of the main valve stem E is transmitted through the roller k, the bell crank l, and the hollow shaft and pinion m, which revolves the pointer around the dial center. The amount of movement around the center depends upon the opening of the valve, and the distance of the end of the pointer from the center of dial depends on the steam pressure per sq. in. between the limits of the meter of 50 and 100 lbs.

The size of the pipe and meter determines the maximum possible horse-power on the dial, while the number of the spring determines the range of pressure. In measuring exhaust steam for heating, the spring and dial are designed to show a pressure from 0 to 30 lbs. absolute, and the dial may indicate pounds of steam instead of horse-power. If the steam pressure upon which the horse-power of the engine is based is 150 lbs. then the meter spring and dial would show a range of horse-power from 0 to full meter capacity and a pressure range from 125 to 175 lbs. or greater range if desired.

By carrying extra springs and dials to correspond, meters for any range may be furnished from stock on short notice, fully graduated for the pressure desired.

It was the intention to calibrate each meter sent out, but when two or more of the same size are calibrated in series the indications correspond so closely that it is expected that the calibration of only one of a size and range will be found sufficient.

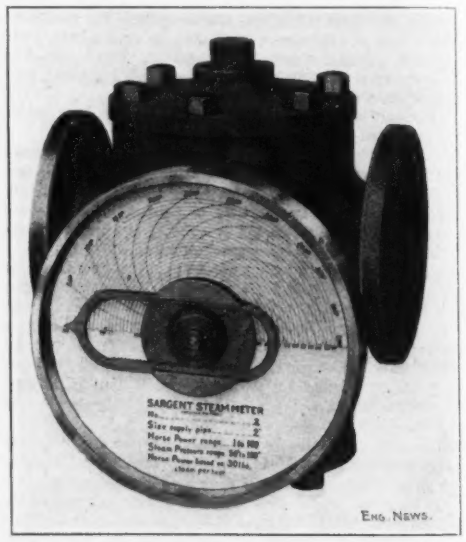


Fig. 4. Front View of 2-in. Sargent Indicating Steam-Meter.

The spring should be of steel, heavily nickel-plated. This meter may be inserted in the steam pipe, either next to the boiler, in which case no separator need be used, or next to the engine, in which case a separator between the meter and boiler as close to meter as possible should be used, and a drum having four times the capacity of the first cylinder at its average cut off should be placed between meter and engine to get a constant flow through the meter and a practically stationary position (non-oscillating) of the pointer.

DIAGRAMS FOR INVESTIGATING THE FUEL CONSUMPTION OF LOCOMOTIVES.*

By G. R. Henderson, M. Am. Soc. M. E.†

The fuel bills of a railroad constitute ordinarily about 10% of the total expense of operation, or from 30 to 40% of the actual cost of running the locomotive. On important systems the gross amount of coal burned assumes a very large figure—running into millions of tons. Each engine will probably consume $5,000 worth of coal in a year on the average, so that for 1,000 locomotives the annual coal bill would approximate $5,000,000. While this is one of the largest items of expense, there is probably less actually known about it than any other account.

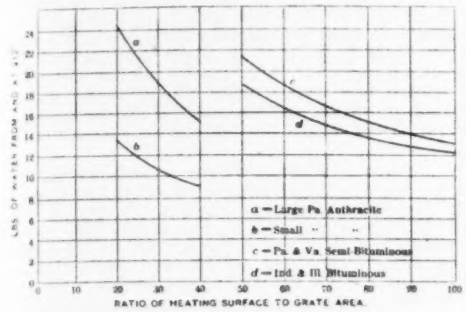


Fig. 1. Maximum Locomotive Boiler Evaporation per Square Foot of Heating Surface per Hour, for Various Heating Surface Ratios and for Different Coals.

We may know in a general way that an engine of a certain class, loaded with a definite tonnage, will haul its train in a given direction over a particular division with a consumption of so many pounds of coal per 100 ton-miles, but here our knowledge stops, and if it should be asked how much is used in ascending the maximum grade, how much on the subordinate grades, and what quantity on the level, there is little likelihood of receiving a correct answer.

The reason for this lack of definite information is not hard to find; in fact it is quite obvious. While it is a comparatively simple matter to determine the quantity of coal used on a trip throughout a run, by means of track scales and measured supplies taken en route, it is very difficult and laborious to subdivide it between terminal points, in the proper proportion to the work done on each of the various grades. An approximation is sometimes obtained by counting the shovelfuls thrown into the firebox between different points, but this, of course, cannot be considered an accurate method. The ordinary exigencies of railroad traffic are so many and varied that it is almost impossible to maintain fixed conditions for a length of time sufficient to determine factors of unquestioned value.

The same comments apply equally to the consumption of water. Even if meters be placed in the feed pipes, the inconvenient location for observation and the variable methods of working the injector by allowing different heights of water in the boiler, not to speak of leaks and wastes, militate against accurate measurements. Thanks, however, to locomotive testing plants we are now able to work an engine for a long period under constant conditions, and at the same time make accurate measurements of the fuel and water consumed.

Several years ago, when connected with the Chicago & Northwestern Ry., the author was able to make a complete set of tests with the standard heavy freight engine of that road, first on the testing stand and afterwards in road service with a dynamometer car. Using the results of these tests as a foundation, it has been found possible to elaborate a diagram for practically any particular locomotive whose general dimensions are known, which will give at once the coal consumption per mile or per hour for various grades and speeds or train loads. This diagram is based upon theoretical as well as practical considerations, and will, it is believed, give values agreeing closely with actual conditions.

The construction of the diagram and the method of using it can, perhaps, be made most clear by assuming a locomotive of certain proportions, and developing the study for this engine. We will therefore consider a consolidation or 2-8-0 locomotive having the following general dimensions:

Diameter of Cylinders	21 ins.
Stroke of piston	32 ins.
Diameter of drivers	56 ins.
Boiler pressure	200 lbs.
Grate area	40 sq. ft.
Heating surface	3,200 sq. ft.
Weight of engine and tender	150 tons.

The theoretical tractive force of such a locomotive will be

$$\text{Theor. Pull} = \frac{P\,d^2\,s}{D}$$

where P = Boiler pressure in lbs. per sq. in.
d = Diameter of cylinder in inches.
s = Stroke of piston in inches.
D = Diameter of drivers in inches.

When we allow for drop in steam pressure and internal resistance, we find that the available tractive force at circumference of the drivers is only 8-10ths of the theoretical tractive force, or

$$\text{Actual pull} = \frac{.8\,P\,d^2\,s}{D}$$

for simple engines, when working at slow speeds with the reverse lever in the corner notch.

For the engine under consideration we therefore find as follows:

$$\text{Theor. Pull}, \frac{200 \times 441 \times 32}{56} = 50{,}000 \text{ lbs. (approx.)}$$

$$\text{Actual Pull}, .8 \times 50{,}000 = 40{,}000 \text{ lbs. (approx.)}$$

As the speed of the locomotive increases, however, beyond the point where the boiler can supply the complete volume of the cylinders at each stroke, an earlier cut-off must be used, and it is necessary to determine the effect of such a change. In order that this may occur at the maximum possible speed, the boiler must be worked to its full capacity, which is limited by its ability to burn fuel.

From various tests it seems as if this limit might be considered as stated below, the quantities being expressed in pounds of coal per square foot of grate area per hour:

Bituminous coal	200 lbs.
Anthracite, large sizes	100 "
Anthracite, small sizes	60 "

We will assume that our engine is burning Pennsylvania or Virginia semi-bituminous coal, therefore, the maximum combustion will be 40 × 200 = 8,000 lbs. coal per hour. This is a large amount to be handled by one man for any great length of time, but there is no doubt that it could be burnt, if supplied. In order to determine the quantity of steam generated by this amount of fuel in the boiler which we have assumed, the diagram, Fig. 1, is introduced. This has been compiled from various sources of information, and, it is thought, fairly represents the average practice in this country. In this figure, the ordinates give the maximum evaporation in pounds of water from and at 212° F. per square foot of heating surface per hour, that can be expected under ordinary conditions, as stated above; the abscissas denoting the ratio of heating surface to grate area. For the engine in question this will be 3,200 ÷ 40 = 80, and for semi-bituminous coal, curve c in Fig. 1, we find that with a ratio of 80, 15 lbs. of water from and at 212° may be evaporated per hour from each square foot of heating surface, or for the boiler as a whole, 3,200 × 15 = 48,000 lbs. per hour. The factor of evaporation from ordinary temperatures of feed water will be about 1.2, so that we shall have, at boiler pressure 48,000 ÷ 1.2 = 40,000 lbs. per hour.

The steam will be somewhat reduced in pressure at the cut-off point, however, and the table here given indicates

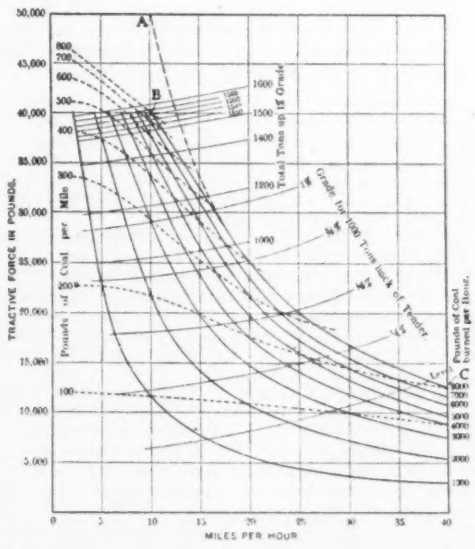


Fig. 2. Locomotive Performance Diagram, Giving Relation Between Draw-bar Pull, Speed, and Rate of Firing.—For a Specified Consolidation Locomotive.

the probable relation of this pressure to the boiler pressure, when the reverse lever is in the corner notch, and the throttle wide open:

Ratios of Cut-off Pressure to Boiler Pressure.

Revs. per min.	Starting.	50	100	150	200
Long ports	.98	.94	.88	.83	.78
Short ports	.98	.92	.85	.77	.72
Medium ports	.98	.96	.86	.80	.75

By long ports is meant those in which the length of port in inches divided by the area of the cylinder in square inches is approximately .12, and by short ports, where this ratio is about .06.

If we assume .90 for the pressure ratio in the case in hand, we shall have 200 × .90 = 180 lbs. at cut-off, which steam will weigh .432 lbs. per cu. ft. The volume of a cylinder 21 ins. diameter and 32 ins. long is 6.4 cu. ft., or for one revolution two cylinders will consume four times this amount or 25.6 cu. ft. No allowance is made for clearance, as the cut-off, with lever in the corner, is usually about 90 or 92% of stroke. For each revolution, then, the steam consumption will be 25.6 × .432 = 11.06 lbs. Then 40,000 ÷ (60 × 11.6) = 60 r. p. m. is the maximum speed at which the boiler will furnish steam at full stroke. The speeds in miles per hour cor-

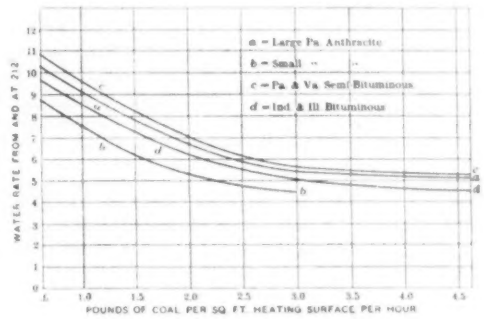

a = Large Pa. Anthracite
b = Small " "
c = Pa. & Va. Semi-Bituminous
d = Ind. & Ill. Bituminous
WATER RATE FROM AND AT 212
POUNDS OF COAL PER SQ. FT. HEATING SURFACE PER HOUR

Fig. 3. Diagram Giving Locomotive Boiler Evaporation per Pound of Coal, for Various Rates of Firing.

responding to the revolutions per minute for a 56-in. wheel are as follows:

5	10	15	20	25	30	35	40 miles per hour
30	60	90	120	150	180	210	240 r. p. m.

Therefore it is plain that above 10 miles per hour the cut-off must be reduced, diminishing the available tractive force of the engine.

A study of the variation in tractive force due to speed indicates that the method explained below gives a close approximation to actual results. In the diagram, Fig. 2, ordinates represent tractive force in pounds, and abscissas the speed in miles per hour. As the maximum speed at full stroke was found to be 60 r. p. m. or 10 miles an hour, we find the intersection of this speed with the theoretical tractive force at A. We therefore construct an equilateral hyperbola through this point, that is, a curve the product of whose ordinates will always have the same value, viz., 50,000 × 10 = 500,000. As we have seen, the available tractive force, however, cannot exceed 40,000 lbs. By drawing from the point B a tangent to the hyperbola, we then have a locus consisting of a straight line and a curve, and this locus gives us the maximum available tractive force (at circumference of the drivers) for which the boiler will supply the cylinders at any speed. But to do this, we must burn 8,000 lbs. of coal per hour, so that the locus BC also gives the combinations of speed and available tractive force which may be obtained by the combustion of 8,000 lbs. of coal per hour.

The rate of combustion per square foot of heating surface per hour is 8,000 ÷ 3,200 = 2.5, and from Fig. 3, (curve c) we should expect 6 lbs. of water per lb. of coal from and at 212°, or a total steam production of 8,000 × 6 = 48,000 lbs., which is the same as our first figure. If the rate of combustion be reduced, however, there will be more steam generated per lb. of coal, as indicated by Fig. 3. For instance, if ¾ the amount be consumed, or 6,000 lbs., the rate of combustion will be 6,000 ÷ 3,200 = 1.87 lbs. per sq. ft. of heating surface, and from Fig. 3 the evaporation will be about 7 pounds of water per pound of coal. Then 7 × 1.87 = 13.09 lbs. of water will be evaporated per square foot of heating surface per hour, instead of 15 lbs. as before. This would supply the cylinders at full stroke for a speed of 15 : 13.09 :: 10 : 8.7 miles an hour. From this as a starting point, in Fig. 2, we construct a new hyperbola and tangent as before, which locus gives the combinations of speed and tractive force for 6,000 lbs. of coal an hour. In the figure, the loci have been drawn for each thousand pounds per hour from 1,000 to 8,000.

If, now, we divide the quantities per hour by the speed, we obtain the fuel consumption per mile, and this is shown by the dotted lines. Thus, with a tractive force of 20,000 lbs. and a speed of 15 miles an hour, we should expect an hourly consumption of 3,000 lbs., or 200 lbs. per mile.

But as our diagram Fig. 2 is based on speed and tractive force as co-ordinates, we can construct additional curves, which may represent the force needed to pull various trains at different speeds or up grades. For instance, if we consider a train of 1,000 tons weight back of tender, or 1,150 tons total weight, we can lay down the curves of resistance for a level, ¼, ½, ¾ and 1% grade, as shown in the diagram. By this means we can determine the quantity of coal that would be used on different portions of a division.

*A paper read before the American Society of Mechanical Engineers at New York, N. Y., December, 1904.

†Consulting Engineer, 20 West 34th St., N. Y. City.

If there were 40 miles each of level, ½ and 1% grade, the fuel consumption would run as follows:

														lbs.
40	miles	@	38	miles	an	hour,	210	lbs.	per	mile..	=	8,400
40	"	@	24	"	"	"	330	"	"	"	..	=	13,200
40	"	@	17	"	"	"	490	"	"	"	..	=	19,600
Total.....														41,200

It will be noticed that this considers the train to be run at the maximum speed which the engine can make on each grade or portion of track. If the speed be limited to 15 miles an hour uniformly, we should expect consumption as follows:

														lbs.
40	miles	on	level	@	50	lbs.	per	mile.....	=	2,000
40	"	"	½%	grade	@	190	lbs.	per	mile.....	=	7,600
40	"	"	1%	"	@	430	"	"	"	.....	=	17,200
Total														26,800

This trip of 120 miles will, however, require 8 hours for its completion, whereas the first schedule is a trifle over 5 hours. The coal consumption in the first case is over 50% greater than in the second case. The effect of speed upon the coal pile is clearly shown by following any of the grade lines in the diagram. The rate per mile on a ½% grade will be about as given below.

Miles per hour	5	10	15	20
Coal per mile, lbs.....	150	160	185	250

The influence of loading is shown by the curves marked "Total tons up 1% grade." At 10 miles per hour the coal consumption is:

250	lbs.	per	mile	for	1,000	tons.
325	"	"	"	"	1,200	"
500	"	"	"	"	1,400	"
630	"	"	"	"	1,500	"
680	"	"	"	"	1,520	"
720	"	"	"	"	1,540	"
780	"	"	"	"	1,560	"

The differences are most marked as the limit of capacity of the engine is approached.

Again, 1,600 tons can be hauled at 5 miles an hour with a consumption of 500 lbs. per mile, whereas 1,570 tons at 10 miles an hour will require 800 lbs. per mile, both cases being the maximum that the engine can do.

These examples give an idea of the variety of problems in fuel consumption which can be quickly solved by the aid of the diagram, Fig. 2. It is true that a different diagram must be made for each class of engine, but this is a comparatively small matter. With the increase in speed and loads of the present day, the coal consumption becomes a topic of great interest, and when comparisons are made with previous schedules, there is an apparent decrease in the economy of fuel, unless the various points are duly considered, and as explained by the chart.

WATER-WASTE INVESTIGATIONS BY MEANS OF PITOMETERS AT CHICAGO.

Water-waste investigations at Chicago were conducted during the four months ending Nov. 1, 1904, by means of the Cole-Fiad pitometer, under the direction of Mr. Edward S. Cole.* The following information has been extracted from a report made by Mr. Cole to Mr. John Ericson, City Engineer of Chicago:

As a part of the investigation a number of the pumping engines were tested for slippage. The slip was found to range from 2.9% on 20,000,000 gallons nominal pumpage on a Worthington pump at the Central Park Avenue station, to 28.5% on a 35,800,000-gallon nominal pumpage for a Quintard pump at the West Side station. Another large Quintard pump at this station showed 20.7% slip.

The report contains the accompanying interesting table (I.) showing slippage tests by means of the pitometer in a number of other cities.

As a result of the slippage tests in Chicago it was concluded that, on an average daily pumpage for the whole city of about 400,000,000 gallons per day for the year 1904 there was a total loss of action in all the pumps aggregating some 25,000,000 gallons a day. On the basis of a population of 1,600,000, indicated by a recent school census, the 375,000,000 gallons actual daily supply would represent a per capita consumption of over 230 gallons.

To test consumption and waste on a large scale five districts were selected for pitometer observations. The investigations in these districts do not appear to have been completed, or, at least, are not fully reported on. The results as given are shown in Table II. The foot-note to the table describes the several districts.

District No. 1 is South Chicago as a whole with its well-known mills and working population.
District No. 2 is "West Pullman," a new and growing section largely made up of factories.
District No. 3 is the large parks—Washington and Jackson—with the Drexel Boulevard extending to 39th St.

*Consulting Engineer, 220 Broadway, New York City.

TABLE I.—Pump Slippages in a Number of Cities as Determined by Pitometer Measurements.

Capacity million gallons daily.	Make of pump.	City.	Description.
10	Worthington	Norfolk, Va	High duty, inside packed.
4	Gaskill	" "	" " "
1	Flanders	So. Bend, Ind	Power driven, inside packed.
1	"	" " "	Power driven, valves newly overhauled.
6	Deane	" " "	Duplex, inside packed.
3	"	" " "	" " "
1½	"	Oskaloosa, Ia	Comp. ring and plunger.
5	Holly	Columbus, O.	Ring and plunger, inc. jet condensers.
5	"	" "	" " "
5	Worthington	Cleveland "	Inside packed.
5	Holly	" "	" " "
10	Blake	New York	Vertical triple, inside packed (valves were adrift).
1	Worthington	Brooklyn	Well pumping station.
10	Holly	Dayton, O.	New vertical triple single act. plungers, outside packed.

District No. 4 is "Hyde Park," a high-class residence district chiefly.
District No. 5 is the square mile comprising the Union Stock Yards (supposed to be entirely metered).

Mr. Cole points out in his report that the per capita consumption in Districts Nos. 1 and 4 is very much below the average of 230 gallons for the whole city. He believes that a subdivision of these districts would show that a small part of the area of each of them is responsible for a large part of the waste indicated by so high per capita figures.

District No. 5 was gaged by means of five pitometers. The readings of consumers' meters for the month September 17 to October 17 were secured from the Meter Department. Mr. Cole states: "The apparent loss of 2,660,000 gallons unmetered daily should be diminished by about 150,000 gallons daily, which we estimate as a reasonable allowance for the small resident population (3,000) within the district."

THE DANGER OF A WATER FAMINE IN NEW YORK CITY.

The dangerous nearness of New York City to a water famine is forcibly shown in a report dated last September and just made public. The report was made to the New York Aqueduct Commission by Mr. J. Waldo Smith, M. Am. Soc. C. E., Chief Engineer, and was endorsed by Prof Wm. H. Burr, M. Am. Soc. C. E., Consulting Engineer to the Commission. The report was brought out by certain allegations by the New York State Labor Bureau relating to employing men more than eight hours a day on several contracts, among which was the New Croton Dam. Mr. Smith states that overtime on the dam was considered entirely justified as coming within the provision of the law that specifically permits overtime in cases of extraordinary emergency caused by fire, flood, or danger to life or property. How great the emergency is Mr. Smith indicates as follows:

The City of New York is now using from the present Croton watershed approximately 300,000,000 gallons of water a day. This is an increase over last year of about 30,000,000 gallons per day, which is attributable to change in distribution by which the Croton water is used over a more extended district, and also to a better pressure being furnished, especially in the high service.

Mr. Hill, the former Chief Engineer of the Department of Water Supply, estimated that within a very short time the use of Croton water would be increased to 310,000,000 gallons a day. It was 307,000,000 gallons a day during July. The average daily consumption of Croton water for the years 1900 to 1903, inclusive, was as follows: 1900, 249,000,000 gals.; 1901, 256,000,000 gals.; 1902, 262,000,000 gals.; 1903, 267,000,000 gals.

The maximum safe yield of the Croton watershed, with the present reservoirs, is, under the most favorable conditions, only 250,000,000 gallons per day, a figure which has been established by Mr. John R. Freeman in his report to the Comptroller in 1900, by the engineers of the Merchants' Association employed to make a report about the same time, and by the Commission on Additional Water Supply, Prof. W. H. Burr, Rudolph Hering and John R. Freeman. These figures are based on actual recorded conditions and results of measurements in the Croton watershed, checked by comparison with other similar watersheds where measurements have been kept for many years. This means that the amount now being drawn by New York each day is 50,000,000 gallons, or 20% of the available supply in dry years, and it is only the special providence of the Lord during the last four years in sending more than the usual quantity of rainfall favorably distributed, that has preserved the city from the danger to life, health and property consequent upon a water famine.

In order to show the conditions more convincingly, I have taken the actual quantities left in the present storage reservoirs at the lowest points in the year 1891-92, 1892-93, 1895-96 and 1900-01, respectively, these being ordinarily dry years, and corrected them for the differences in the draught from the Croton watershed between those years and that obtaining the present year.

This computation indicates that with the present available storage in the Croton watershed and with flows of the river like those actually occurring in the years mentioned, the reservoirs would have been entirely empty for considerable periods, as shown in the following table, assuming a draught of 300,000,000 gallons per day from the present Croton reservoirs and the actual yield of the Croton watershed as measured:

Year.	Approximate periods storage reservoirs would have remained empty.
1891-92	38 days.
1892-93	84 "
1895-96	56 "
1900-01	44 "

This shows that within nine consecutive years the storage capacity would have been entirely exhausted for four considerable periods, and the city dependent upon the natural flow of the Croton River, which, at times, is less than 50,000,000 gallons per day. If we go back to the earlier periods of extreme drought, such as 1880-83, the conditions are very much worse.

The completion of the New Croton Dam and the filling of the reservoir would add 30,000,000,000 gallons, or 100 days' draft, to the available supply.

The facts as presented, the report states, warrant the assumption that an emergency exists which justifies working the men overtime. The men have been paid pro rata for their overtime, and no one has been forced to work more than eight hours, but all, so far as Mr. Smith could learn, "glad of the opportunity to work."

RAILWAY GRADE CROSSINGS of steam and electric railways are held by the Attorney-General of Illinois to be under the jurisdiction of the State Railway and Warehouse Commission. The street and interurban electric railways have held that the Commission had no power of regulation over them, on the ground that the term "railway" means "steam railways." The decision of the Attorney-General strengthens the position of the Commission in its endeavors to prevent the construction of grade crossings and to compel the protection of all existing crossings by means of interlocking plants.

ANNUAL MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS AT NEW YORK CITY.

The fiftieth meeting of the American Society of Mechanical Engineers, which was also the twenty-fourth annual meeting, was held in New York City on Tuesday to Friday, Dec. 6 to 9, 1904. A strong program of technical papers was considered, a program which dealt almost exclusively with machinery, tools, and apparatus, or tests thereof. The discussion of Shop Management and similar general subjects, which has been such a large feature of the last half dozen meetings of

TABLE II.—Results of Pitometer Tests of Water Consumption at Chicago.

Date.	District Number. 1 July.	2 Aug.	3 Sept.	4 Aug.	5 Sept. and Oct.
Total population	51,263	23,863	.....	56,133	3,000 Est.
Average daily supply, gals., 24 hours	6,771,000	4,890,000	1,130,000	9,500,000	16,800,000
Average daily metered supply, gals., 24 hours	1,170,000	.....	.....	1,500,000	14,140,000
Average daily unmetered supply	5,601,000	.....	.....	8,000,000	2,660,000
Per capita total supply daily	132	206	.....	169	.....
Per capita metered supply daily	23	.....	.....	27	.....
Per capita unmetered supply daily	109	.....	.....	142	.....

the society, was absent. Some four or five of the papers are reprinted in extenso on other pages of this issue, while the others are summarized below, together with the discussion that was elicited.

The official business transacted at the meeting comprised three main items: the election of officers, the discussion of a proposed constitutional amendment, and the reception of two interesting mementos, the gifts of members.

The ballot for officers resulted in the confirmation of the ticket presented by the nominating committee. The new officers are: President, Mr. John R. Freeman, of Providence, R. I.; Vice-Presidents, Mr. Samuel M. Vauclain, of Philadelphia, Pa., Mr. H. H. Westinghouse, of New York, N. Y., and Mr. Frederick W. Taylor, of Philadelphia, Pa.; Managers, Mr. George M. Brill, of Chicago, Ill., Mr. F. J. Miller, of New York, N. Y., and Mr. R. H. Rice, of Providence, R. I.; Treasurer, Mr. Wm. H. Wiley, of New York, N. Y.

At the opening session of the meeting, on Tuesday evening, Dec. 6, President Ambrose Swasey delivered the presidential address, a brief but suggestive review of a few achievements in wonderful accuracy, under the title, "Some Refinements of Mechanical Science." This address appears on another page of this issue. Immediately following, Mr. C. W. Hunt addressed the society to present, on the behalf of an unnamed donor, a portrait of Professor John E. Sweet, of Syracuse, N. Y. Professor Sweet is one of the founders of the society, and to his activity and influence the success of the society's early years is largely attributed.

At the last session of the meeting Mr. James M. Dodge, of Philadelphia, Pa., presented to the society a bronze bust of Captain John Ericcson, the man who "twice revolutionized the science of naval architecture," as Mr. Hunt's presentation address had phrased it a few days before. The bust is a copy of a plaster bust made in the prime of the great engineer's life, a bust which was acknowledged by him to be an excellent likeness. The plaster bust had never been duplicated or reproduced in more enduring form until Mr. Dodge had this bronze replica prepared as a gift to the society.

The discussion of a constitutional amendment proposed by Mr. F. J. Miller was very animated, and consumed nearly two hours of time. The proposed amendment aimed to change the present procedure in amending the constitution, and was itself amended by a change proposed by Mr. A. W. Jacobi, and approved by Mr. Miller. The Miller amendment, originally moved at the Chicago meeting, June, 1904, and the Jacobi amendment had been sent out to the members in an official circular, giving notice that they would be brought up for discussion at this meeting, for vote as to whether they were to be sent out for final ballot by the membership-at-large. It is provided, in the present procedure, that twenty favorable votes at the meeting will order the amendment to be sent out for general ballot. Mr. C. W. Hunt thereupon moved to amend the Jacobi amendment by retaining the present clause of the constitution. If this motion had been sustained and carried, it would have nullified the 20-vote provision, and therefore defeated Mr. Miller's attempt to amend the constitution. As a matter of fact, President Swasey sustained the motion, and thereupon discussion began. Mr. Jesse M. Smith and Mr. C. W. Hunt spoke in defense of the present clause of the constitution, while Messrs. F. J. Miller and G. C. Henning led in advocating a change. The motion of Mr. Hunt however, brought much support to Mr. Miller's side; Messrs. F. W. Taylor, Geo. I. Rockwood, H. L. Gantt, and others attacked Mr. Hunt's motion as in opposition to the plain intent of the present constitution, since if carried it would nullify the present 20-vote clause to which any proposed amendment is entitled. As a result of this opposition, Mr. Hunt finally withdrew his motion. Vote was then taken on the Jacobi amendment, which failed to receive a majority. Thereupon Mr. Miller himself declared his opposition to his own amendment, and in consequence it failed to poll the necessary 20 votes and was killed.

The Council's report, including reports of standing committees, etc., showed the greatest yearly increase in membership yet recorded. The present list is about 2,800, of which about 250 were added during the past year. The report also shows, however, that the expenditures of the society for the year exceed the income from dues by $2.68 per paying member, and exceed the income from all sources (initiation fees, etc., included) by $0.15 per paying member. It also calls attention to the fact that by July, 1905, the society will be required to pay $8,000 on account of land for the Union Engineering Building, of which amount more than $2,000 still remains to be collected.

Other business included brief progress reports from the committees on the Union Engineering Building, on the Union Engineering Building Library, on the History of the Society, and on the Robert H. Thurston Memorial Bust. The Library committee reported that present plans are for a consolidated library of broad basis, the nucleus of the greatest engineering library in the country.

Col. E. D. Meier drew attention to the coal-testing plant established at the St. Louis Exposition, which through lateness in beginning work has not yet completed over a fourth of its planned work. Already 85 complete tests of coals have been made, but some 250 more can be tested if the plant is continued. In order to aid in obtaining a further appropriation from Congress to continue this work, it was voted that the Secretary be instructed to address the members asking them to take the matter up individually with their Congressmen.

Technical Proceedings.

The professional work of the meeting was begun by Mr. A. F. Nagle (Buffalo, N. Y.), with a paper entitled "A New Hydraulic Experiment." Essentially, this paper calls attention to the fact that when, in a piping system, a valve is closed there remains in the system a definite amount of kinetic energy of moving water, which must be absorbed by some means, as by the rise of water in a standpipe above its normal level. An experiment is recited which was made for the purpose of exhibiting this fact. A simple formula equating the kinetic energy to the work required to raise a column of water is derived, and curves are given which show that the observed rise is materially below the computed rise (because of pipe friction, etc.). Mr. G. W. Colles (Milwaukee, Wis.), and Prof. R. C. Carpenter (Ithaca, N. Y.), submitted brief discussions, the latter calling attention to Joukovsky's complete analytical treatment of the subject of water hammer. This Russian work has been summarized by O. Simin before the American Water-Works Association (see Proceedings of that association for 1904). A communication from Sir Benjamin Baker (London, Eng.) reported a case of water hammer in a pumping line, which occurred about twenty years ago. A line of cast-iron pipe supplied water to pumps which could be driven either by turbines or by steam engines. Repeated fractures of the pipe led to Mr. Baker being called in. He found that the breakages were noticed soon after starting or stopping the pumps; it was also discovered that no trouble resulted when the turbines were used for driving the pumps. The conclusion was that the sudden starting or stopping of the steam engine sent a pressure wave through the pipe, and this caused the fractures. He recommended that a screw device be fitted to the engine throttle, so that it would take at least a minute to start or stop the engine. This was done and no further fractures appeared.

THRUST AND MOMENT OF TWIST DRILLS.

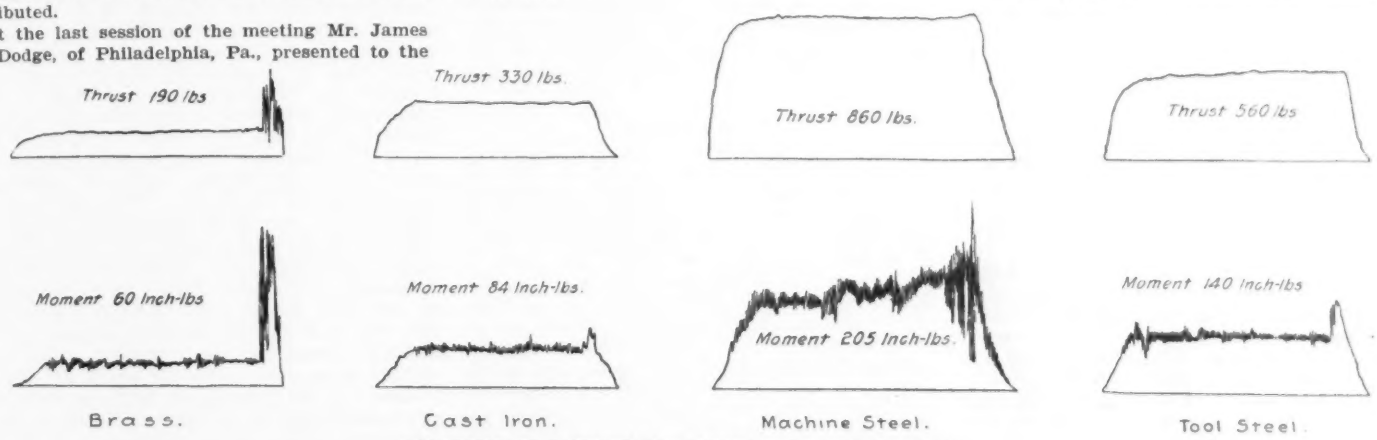
An interesting device was described by Messrs. W. W. Bird and H. P. Fairfield, under the title, "A Twist Drill Dynamometer." The device in question was planned and built for the purpose of obtaining diagrams of thrust and turning moment of twist drills working in various materials. The arrangement used is quite simple, as will be understood from the following description:

The thrust and moment are measured by the forces required to hold the block upon which the drill is working. The drill is fixed, horizontally, in the spindle of a milling machine. A suitable chuck for clamping the piece of work is placed on the table of the machine; the frame which holds this chuck is mounted on rollers so that it is free to move toward or from the drill. Its motion away from the drill is resisted by a long self-packing plunger working in a fixed horizontal cylinder. The cylinder is filled with oil and communicates with the cylinder of a small indicator. The rise of the indicator pencil then represents the thrust. The drum of the indicator is turned by a string attached to the machine spindle, so that the abscissas of the resulting thrust diagram will represent the penetration of the drill.

The chuck which holds the work is mounted on a stem which works in bearings placed in the line of the drill axis. Thus the chuck can turn freely, roller bearings being provided to minimize the friction of this motion. A flexible band attached to the periphery of the chuck is connected at its other end to the piston of a second indicator, and thus moves the pencil of this indicator proportionately to the turning moment exerted by the drill on the work. The drum motion of this indicator is obtained from the drill spindle as before.

Thus two diagrams are obtained, one for longitudinal thrust and one for turning moment.

Diagrams thus obtained, for a ⅝-in. standard drill working in four different materials: brass, cast iron, machinery steel and tool steel, are reproduced herewith. As will be seen, brass and machinery steel, especially the former, show a pronounced rise in the moment curve at the end, when the drill is cutting through.



DIAGRAMS OF THRUST AND MOMENT OF TWIST DRILLS.

⅝-in. Standard Twist Drill, Half-Angle of Point 59°, Speed 200 r. p. m., Feed 0.008 in. per revolution = 2.08 ins. per minute.

This device has been used for some experimental investigation of drills and drilling, but only a small part of the field has yet been covered. A study of the point angle of twist drills, for example, showed that the thrust decreased with decreasing point angle. Angles sharper than 45° (90° point), however, caused the point to fail too rapidly. In consequence it is recommended that the point angle of drills be decreased to 45° half angle.

In discussion Mr. F. W. Taylor (Philadelphia, Pa.) stated that the firm of Wm. Sellers & Co. had long ago adopted the 45° angle of drill to which the authors refer. This was done in consequence of a long series of experiments wherein this angle was found to give the best results. Mr. Taylor did not describe the nature of these experiments. He pointed out, however, that the best drill angle depends on the hardness of the material being drilled; with harder material a blunter point must be used, just as cutting tools must be the more blunt as the material is harder, up to a 90° edge for cutting chilled cast iron. The statement of the authors, that to a 90° point is best must therefore be qualified.

DIAMOND TOOLS.

Mr. G. C. Henning (New York, N. Y.) presented a paper on "Diamond Tools," which described briefly the form of tools used for cutting by means of diamonds, and the procedure of making these tools. A new process, in which the setting or holder is steel cast around the stone, the Thermit process being used to obtain the liquid steel in small amounts, was described as offering important advantages; with this form of setting a firmer grip of the stone is obtained, there is less likelihood of losing the stone by grinding away the front of the setting, and smaller stones can be used. The latter applies particularly to dies for wire drawing, in which case a hoop of steel is cast around the stone and great bursting resistance thereby obtained. This paper will be reprinted in another issue of Engineering News.

The paper, which was illustrated by an exhibit of diamond tools, awakened much interest. In reply to a question regarding emery-wheel dressers, the author stated that only "black diamond," the hardest and strongest variety, is used for this service, and rough, i. e., uncut, stones are used. For lathe tools, the stone is fitted with a suitable point as desired, either straight, pointed or round-nosed. A point may be had by using a natural crystal point, but usually the stone is cut and ground to the desired shape.

CENTRIFUGAL FANS.

Mr. A. J. Bowie (San Francisco, Cal.) presented a paper entitled "Centrifugal Fans," which related the results of some experiments on these machines. By means of a special form of Pitot tube, devised to give a reading not only of velocity pressure, but also of direction of flow, the author measured the distribution of radial discharge velocity across the outlet of two or three different fans. He showed that in some fans the radial velocity at the middle of the width of the blade is much lower than near the edges, in fact, sometimes zero or even negative. He claimed special importance for studies of this sort in fan design, on the ground that uniform discharge velocity across the face of the fan is necessary for best efficiency and capacity.

A remark in the paper concerning the deleterious effects of side clearance brought an objection from Prof. R. C. Carpenter (Ithaca, N. Y.), who holds that, within limits, the efficiency of centrifugal fans increases with clearance. He claimed, moreover, that the matter advanced in the paper is not new where it is correct. Concerning the part dealing with Pitot tubes, he stated that this instrument is by no means merely for approximate work, but it is a scientific instrument of great accuracy; its position as such in the case of air tests was established by comprehensive experiments in Prussia twenty years ago, where velocities by Pitot tube were compared with discharges as measured in a large gasometer. The value of the Pitot tube for water velocities is well known. The best forms have been determined and the velocity coefficients accurately found. The type used by the author is neither new nor particularly good.

APPRAISAL OF WATER POWERS.

A long paper, entitled "Some Details Entering Into the Computation of the Values of Water Powers and the Damages Caused by the Diversion of Water Used for Power," was presented by Mr. Chas. T. Main (Boston, Mass.). Tables and diagrams are given in this paper for aid in making the various computations necessary to determine how much it will cost, in a given case, to supply steam power sufficient to replace diverted water power. The argument throughout is based on the assumption that a steam plant is already in existence of a size sufficient to make up the deficient flow of water of the dry season, and the author holds, further, that a factory which is operated without such auxiliary steam plant should be treated as though it had such plant, that is, its damages should be no greater than if it were equipped to run on full power throughout the year. The paper is too long and detailed for further notice here. It was not discussed.

AN INDICATING STEAM METER.

The above is the title of a paper presented by Mr. C. E. Sargent (Chicago, Ill.), wherein is described an instrument resembling a reducing valve fitted with indicating mechanism to indicate the weight of steam passing through in unit time. The paper is reprinted elsewhere in this issue. It was discussed briefly by Messrs. G. C. Henning and H. H. Suplee, the latter calling attention to a German steam meter, designed some years ago, which operates somewhat differently from that of the author. Mr. Henning expressed appreciation of Mr. Sargent's design, but expressed the fear that the mechanism would be deranged by corrosion and erosion of the moving surfaces unless excellently constructed and well maintained.

BOILER STAYS.

A paper on "Staybolts, Braces and Flat Surfaces" was presented by Mr. R. S. Hale (Boston, Mass.), who summarized various authoritative formulas or recommendations as to proportioning staybolts in boilers, and drew some conclusions as to good practice in this field. The paper is printed elsewhere in this issue. In discussion, Mr. G. R. Henderson questioned the author's assertion that overheating of firebox plates is always due to improper operation and should therefore not be considered in the formulas for proportioning flat plates. He instanced a case where a locomotive firebox sheet exhibited serious bulging and cracking, though the stress in the metal was below the limits specified by good authorities. Overheating was suspected, and, in fact, gage cocks inserted from the other side of the water leg showed that when the engine was steaming hard there was a layer of steam along the sheet in question. In cases of this sort there is no remedy in either operation or general design, and lower unit stresses should be used to give the requisite safety. Prof. Wm. T. Magruder (Columbus, O.) reported tests of metal from an old locomotive firebox crown sheet, which showed that the original physical qualities of the steel had become greatly lowered. The stress strain curve had lost its characteristic stepped shape and had become rounded, without definite yield-point; the ultimate elongation had dropped from the original 25 or 28% to a value of 14% at the back of the sheet and as low as 6.6% at the center of the sheet. Such deterioration must be taken account of in the proportioning of firebox plates, if a long life is expected.

CONDENSERS.

Mr. G. I. Rockwood (Worcester, Mass.) brought up the subject of condensers in a paper entitled "Condensers for Steam Turbines." The paper describes briefly a condenser installation at the Atlantic Mills, Providence, R. I., for a 400-KW. Westinghouse-Parsons steam turbine. A 16-in. Bulkley injector-condenser with barometric draft tube was fitted, and no air pump was used. The injection water is elevated by pumping into an air-separating tank, 30 ins. diameter by 15 ft. deep, whose water level is about level with the condenser bulb. A vacuum of 28 to 28½ ins., in one case even 29 ins., is obtained with this outfit. The author's principal argument is for the omission of the air pump, which, he claims, is in many instances the principal source of air leakage. He also contends that steam turbines do not need as large exhaust pipes as are usually fitted; the turbine in question had a 20-in. exhaust opening, but a 16-in. pipe and condenser were found ample. The author even reports that there was no measurable drop in pressure between turbine exhaust chamber and condenser, measured by mercury columns.

This latter statement called out much opposition. Mr. F. Hodgkinson (Pittsburg, Pa.) showed a diagram of fall of pressure in an exhaust pipe proportioned according to present practice, that is far more liberally than Mr. Rockwood's 16-in. pipe. He would expect at least ½-in. drop in the Atlantic Mills exhaust pipe, and explained the discrepancy by stating that mercury gages are apt to be in error unless the greatest care in draining them of water is taken. Mr. Joseph Morgan (Johnstown, Pa.) described a jet condenser plant fitted to steam turbines in the power house of the Citizens' Light & Power Co. of Johnstown. The jet condenser was adopted because cheaper than surface condensers, counting the cost of water. He expressed the opinion that the injector condenser is unsatisfactory in the case of rapidly fluctuating load, such as traction or rolling-mill load, and instanced a case in point. Mr. C. H. Wheeler (New York, N. Y.) said that while the injector condenser has many attractive qualities, especially where the injection water does not need to be pumped, yet it lacks flexibility, such as would be conferred by an automatically expanding throat, for example. It is, therefore, not suited for varying loads. Moreover, as ordinarily operated it consumes more water than other types, as is shown by the lower hot-well temperature. Concerning pressure drop in exhaust pipes, he reported a case where the exhaust was only 10 ft. long, yet showed a drop of 0.3 ins. Mr. G. J. Foran (New York, N. Y.) advanced the opinion that the injector condenser consumes more power than other types. The low condenser costs given in Mr. Rockwood's paper do not, he believes, include enough apparatus to make them suitable for comparison. Regarding the Parsons "augmenter," a recent English device mentioned by Mr. H. H. Suplee, which employs a steam injector to draw air from the main condenser to an auxiliary condenser, and thereby raises the vacuum above that of the air pump, Mr. Foran thought that its effect is only to decrease the size of air pump required, but not to improve the thermodynamic action of the condenser. In conclusion, Mr. Rockwood explained the absence of exhaust-pipe pressure drop, in his tests, as being due probably to the entraining or Pitot-tube action of the moving steam on the gage, which would lower the apparent vacuum in the exhaust pipe. He also reported that in recent visits to three steam turbine stations he had found them running with vacuum of 27, 26 and 22 ins., respectively, which is by no means as high as turbine makers assume, nor as high as good condensing plants should give. Lack of care in getting the piping tight is responsible for this condition.

FLYWHEEL BURSTING TESTS.

Interesting work in the experimental study of strength of flywheels was reported by Prof. C. H. Benjamin (Cleveland, O.) under the title, "The Bursting of 4-Ft. Flywheels." This work was a continuation of earlier work on 15-in. and 24-in. pulleys and flywheels, previously reported before the society. To burst 48-in. wheels involves much greater destructive agencies, of course, than bursting the smaller wheels, and a new, stronger testing plant was required. With this, three wheels were tested, one solid and one split cast-iron pulley, and one built-up wheel of bronze and steel castings. The three wheels reached rim speeds of 230 ft., 125 ft. and 372 ft. per second. The bursting of the third wheel unfortunately wrecked the test casing and prevented further experiments. The paper is reprinted elsewhere in this issue.

Brief discussions were submitted by Messrs. G. C. Henning, G. R. Stetson, F. A. Halsey and J. E. Johnson. Mr. Henning said that the experiments show certain materials to be inherently suited or unsuited for use in high-speed flywheels; that the proper material for the rims of high-speed wheels

is steel, which can be rolled, bent and welded to make a true and homogeneous rim of equal strength at all points, and naturally balanced. Mr. Stetson suggested that in the case of belt flywheels, that is, broad-rimmed flywheels which also do duty as pulleys, an important contributory cause for breakages may be found in the heating of the rim by slipping of the belt as the wheel speeds up. At the Amoskeag Mills, some years ago, after a disastrous flywheel explosion, a wheel with wooden lagging was designed in order to diminish the danger of heating.

COUNTERBALANCING THE CONNECTING ROD.

Mr. Sanford A. Moss (Schenectady, N. Y.) presented a paper, "Influence of the Connecting Rod Upon Engine Forces." This give a mathematical determination of the inertia forces produced by the motion of the connecting rod in an engine, and summarizes the results in simple form. The mathematical analysis is very direct and neat, and merits study in this regard. The procedure is simple: Assuming a uniform angular rotation of the shaft, and with known ratio of connecting-rod length to crank, the algebraic expressions for the position of the connecting-rod are derived. There are three such expressions, respectively for the abscissa and the ordinate of the center of gravity of the rod, and for the angle between rod and engine axis. By differentiating these expressions twice, the corresponding accelerations are obtained, which, when multiplied by the mass and mass moment, respectively, give the active inertia forces. These can be resolved into three forces: (1) A piston pressure; (2) A guide pressure, and (3) A centrifugal force at the crank pin.

The author shows that these three pressures undergo a slight variation as the crank makes its revolution, but that the variation in ordinary cases is only about 2%. It follows that the inertia forces of the connecting rod may be counterbalanced completely (with but 2% error) by supplying: (1) A balance weight on the crank, opposite the crank pin, and (2) A reciprocating balance in addition to the balance provided for piston, piston rod and crosshead. The guide pressure is so small that it may be neglected. The amounts of these two counterbalances, that is to say, the equivalent amounts of weight acting: (1) At the crank pin, as purely rotating weight, and (2) At the crosshead, as purely reciprocating weight, are as follows:

$$\text{Rotating weight} = W\,\frac{K^2}{l^2}.$$

$$\text{Reciprocating weight} = W\left(1 - \frac{K^2}{l^2}\right)$$

where W = weight of connecting rod,
K = radius of gyration of connecting rod around wrist pin,
l = length of connecting rod, between centers of pins.

For the ordinary case, $K^2 \div l^2$ is very nearly one-half, so that a good approximation to absolute counterbalance may be obtained by reckoning half the weight of connecting rod as concentrated at the crank pin, and half at the wrist pin.

NON-CONDENSING ENGINES.

Two papers on engine efficiency were presented: "Losses in Non-Condensing Engines," by Mr. J. B. Stanwood (Cincinnati, O.), and "The Power Plant of the Tall Office Building," by Mr. S. H. Bunnell (Watertown, N. Y.). Mr. Stanwood's paper is an attempt to define and analyze the factors involved in the quantities C and F first discussed by Mr. Willans in 1893. These quantities represent what may be called the condensation efficiency and the expansion efficiency of an engine cylinder. The discussion leads to no direct conclusions, however. The paper of Mr. Bunnell presents the argument that in service under variable load, a four-valve simple engine may be more efficient than a compound engine, both running non-condensing. The argument is made by estimating steam consumption from actual indicator diagrams of the two kinds of engine, and claims to show that at low load the compound non-condensing engine is apt to have losses between the two cards which make it less economical than the simple. The author refers specifically to pumping engines in office buildings, which must be located in restricted space, operate against atmosphere or heating system back pressure, and yet be fairly economical. He suggests that the choice of the more expensive and bulky compound is not well supported.

This argument was strongly attacked by Mr. F. H. Ball (Plainfield, N. J.), who objected to Mr. Bunnell's method of "substituting estimate for engine testing" in drawing conclusions as to engine performance. From Mr. G. H. Barrus' "Engine Tests" he showed that the best Corliss simple engine whose test is there reported was lower all along the efficiency curve than an average compound. A test made by Mr. Ball on a simple engine of another size and type checked closely with the simple Corliss results of Mr. Barrus. He deduces herefrom that a "four-valve" simple, which is less efficient than a Corliss, because lacking the releasing gear, cannot be as efficient as a compound. Mr. J. B. Stanwood analyzed Mr. Bunnell's cards for the factors C and F before mentioned, and found abnormally low condensation losses at short cut-offs, which, he stated, requires further explanation and proof.

A paper on "Pressures and Temperatures in Free Expansion," by Messrs. A. Borsody and R. C. Cairncross (New York, N. Y.), presented a series of tables and diagrams of tests on a De Laval nozzle. Both steam and air were tried, and in each case the pressure and the temperature were measured at many points along the axis. Pressure was observed by a fine longitudinal tube in the axis of the nozzle, having a lateral hole, to avoid Pitot-tube effects. Temperature was measured by a thermo-couple stretched longitudinally through the nozzle, to avoid heating by impact. The curves and tables were presented for record, without analysis or discussion.

LOCOMOTIVE PERFORMANCE.

Two papers brought forward some interesting information on locomotive performance.

Mr. G. R. Henderson (New York, N. Y.), in a paper, "Fuel Consumption of Locomotives," described a diagram which represents the fuel consumption of any given locomotive for any given speed and drawbar pull, or, conversely, the relations between grade, speed, train load, etc., for a given maximum rate of steaming. The paper is reprinted in another column of this issue. In discussion, Prof. W. F. M. Goss (Lafayette, Ind.) stated that while the diagram offered is susceptible of some refinement, it is substantially correct; the St. Louis tests of the Pennsylvania R. R. should yield material by which the diagram can be made more precise. Prof. E. A. Hitchcock, however, held that cylinder condensation at low speeds would radically change the location of the curves in the diagram. Prof. R. C. Carpenter (Ithaca, N. Y.) called attention to the enormous fuel-consuming capacity which the author premises, up to 200 lbs. per sq. ft. or grate per hour. He presented some recent data obtained with forced draft in stationary boiler furnaces; depending upon the kind and size of coal, he found that a maximum of 12 to 28 lbs. of coal per sq. ft. per hr. could be burned. He also referred to the wide variation in actual size between the different makers' nominal sizes of coal, and suggested that the adoption of standard screens for sizing coal would be valuable. Mr. C. B. Rearick (New York, N. Y.) reported a higher combustion rate than that of Prof. Carpenter; in a vertical boiler, with a wire-mesh grate protected by clinker, and ⅞-in. draft, he reached a rate of combustion of 38 lbs. per sq. ft. per hr. Mr. A. A. Cary (New York, N. Y.) reported a maximum of 30 lbs. per sq. ft. from some recent tests of the Delaware, Lackawanna & Western R. R. Mr. Henderson stated that some years ago, when running a locomotive on the testing stand of the Chicago & Northwesern Ry., a single fireman shoveled 6,000 lbs. of coal into a furnace in one hour; but this was on a stationary firing platform (instead of the unsteady platform of a locomotive on the road), and the coal was wheeled up by helpers and dumped close behind the fireman so that he had merely to shovel it into the fire hole. Ordinarily, on a locomotive, 3,000 lbs. per hour would be an upper limit, and this would not be maintained for many hours.

Prof. E. A. Hitchcock (Columbus, O.) presented a paper on "Road Tests of Brooks Passenger Locomotives." This consists mainly of tabulated observations, difficult to summarize. The two locomotives tested were of ordinary size and power, and beyond "squaring up" the valves the locomotives were left in service shape, as they came from the road. As the speeds, economy, evaporation, etc., under these circumstances are representative of ordinary good railway practice, we give some extracts of the results. It will be recognized that the results, as well of boiler and engine as of the machine itself, are very good:

GENERAL DIMENSIONS OF HOCKING VALLEY RY LOCOMOTIVE.

	No. 73.	No. 80.
Weight on drivers	84,000 lbs.	87,000 lbs.
" " truck wheels	44,000 "	46,000 "
Total weight	128,000 "	133,000 "
Weight of tender	95,000 "	102,000 "
Wheel base, rigid	8 ft. 9 ins.	8 ft. 9 ins.
" " total of engine	24 " 1½ "	24 " 0 "
Length of engine	36 " 1½ "	36 " 0½ "
" " " and tender	59 " 3½ "	59 " 4 "
Height of center of boiler above rails	8 " 7½ "	8 " 4½ "
Heating surface, total	1,974 sq. ft.	1,946 sq. ft.
Grate area	30.8 " "	29 " "
Drivers, 4, diameter in ins.	72 ins.	66 ins.
Cylinder diameter	18 9/32 "	18 "
Piston stroke	26 "	26 "
Boiler, type	Belpaire.	Wagon top.
Working steam pressure	180 lbs.	180 lbs.
RESULTS.		
Pan Refuse:		
Combustible	41.62%	48.18%
Ash	58.38%	51.82%
Stack Refuse:		
Combustible	67.68%	73.20%
Ash	32.32%	26.80%
Fuel:		
Weight of coal fired	8,197 lbs.	7,508 lbs.
Before start	1,746 "	1,067 "
During run	6,451 "	6,441 "
Fuel per Hour Steaming Time:		
Actual coal fired	2,757 lbs.	3,081 lbs.
Equivalent coal burned	2,421 "	2,693 "
Combustible burned	2,007 "	2,187 "
Actual coal fired per sq. ft. grate	89.5	106.2
Equivalent coal burned per sq. ft. grate	78.6	91.8
Combustible burned per sq. ft. grate	65.1	75.4
Combustible burned per sq. ft. heating surface	1.01	1.12
Water Per Hour Steaming Time:		
Equivalent evaporation per hour from and at 212°	16,770	18,400
Equivalent evaporation per hour from and at 212° per sq. ft. heating surface	8.49	9.45
Horsepower developed by boiler (34.51 lb. rating)	486	533
Economic Results:		
Water apparently evaporated under actual conditions per lb. of coal as fired	6.81	6.33
Equivalent evaporation from and at 212° per lb. of combustible burned	11.1	10.6
Engine Performance:		
Number of cars in train	4	4
Gross load in tons	143	143
Total miles	123.7	123.7
Aver. speed in miles per hour	47.4	52.4
" revolutions per minute	221	266
Steam pressure by gage	174	157
Horse-power, total	629	705
Safety valve, number of times popped	29	3
Safety valve, number of seconds on	1,630	150
Safety valve, lbs. steam escaped	1,596	340
Steam lost at calorimeters and aspirator	227	224
Dry steam lost by pop, calorimeters and aspirator	1,823	564
Dry steam lost by engine and air pump	41,544	39,711
Total hours throttle open	2.34	2.09
I. HP.-hrs.	1,472	1,472
Pounds dry steam per I. HP. per hr., including air pump	28.2	27.0
Dry steam used by air pump	753	750
Pounds dry steam per I. HP. for engine alone	27.7	26.41
Ton-miles	17,690	17,690
Pounds coal per ton-mile	0.364	0.364
" steam per ton-mile	2.31	2.2

The maximum speed in these two runs was about 80 mi. per hr. in either case, and the maximum indicated power 1,383 I. HP. and 935 I. HP., respectively. The lower maximum power in the latter case is because of more uniform running.

In discussion, Mr. H. DeB. Parsons (New York, N. Y.) presented the results of some locomotive road tests made by him recently. The remainder of the discussion related to the question of firing locomotives, suggested by the high actual rates of firing shown in Prof. Hitchcock's tests. Some expressed the opinion that practice tends inevitably toward the automatic stoker, and Mr. G. R. Henderson (New York, N. Y.) said that recently he saw the trial of an automatic stoker for locomotives which fed 17,000 lbs. of coal in one hour. A query as to the feasibility of feeding pulverized coal, just as in cement kilns, led to a detailed re-

ply by Mr. A. A. Cary, who pointed out the difficulties of storing, of preventing excessive absorption of moisture, of providing against the concentrated high temperature in the firebox, etc., which make pulverized fuel impracticable for locomotives.

STEAM BOILERS.

Mr. A. Bement (Chicago, Ill.) presented a long paper, entitled "A Bad Case of Discharge of Water with Steam from Water-Tube Boilers." The case described was that of boilers supplying two engines of about 10,000-HP. aggregate capacity. The steam pipe was not very long, and the total steam storage space, from boiler water level to engine valves, was rather small. The draft of steam by the engines, while the admission valves were open, caused slight variations in pressure in the boilers, which, though barely measurable, were sufficient to release large quantities of steam in the boilers; in other words, the revolution of the engine was accompanied by a cycle of steaming, consisting of a very short period of violent ebullition and a much longer period of normal steaming. In the boilers in question, the front header connecting the water tubes connects to the steam drum directly below the steam pipe. A horizontal baffle at the middle of the height of the drum is intended to deflect the rising column of water and steam backward toward the rear of the drum, allowing only dry steam to go into the steam pipe. Mr. Bement discovered that the baffles did not do their work, large quantities of water going around the baffle and into the steam pipe during the period of heaviest draft. The problem was studied thoroughly by means of a small glass model, and a more suitable arrangement of baffle was developed.

In the course of this work two further facts were discovered: (1) That calorimeter readings do not, in the case of serious water entrainment, give correct readings of the free water in the steam pipe; and (2) that a separator may not separate a drop of water, probably in the case where the velocity of steam flowing through it is too great. The question of calorimeter readings is important. Mr. Bement says:

> The usual method employed to determine whether boilers are discharging wet steam is to test with a calorimeter. One hundred and forty-three such tests were made on boilers of group No. 3, the results of which are most interesting, and prove the utter fallacy of this business as far as getting an average sample is concerned. It is the author's opinion that the water in a vertical pipe will flow in contact with the walls; for this reason a sample taken from the center of the pipe cannot show an average percentage of water. For this reason the sampling pipes, which were duplicates of each other, were perforated for their whole length, so that if possible the sample would be gathered uniformly from the center to surface of the pipe, with the idea of securing any water traveling along the pipe. The 0.5-in. pipes were each bushed with a 0.25-in. pipe, and twenty $^{3}/_{16}$-in. holes drilled through each, and the inner ends of the sampling pipes were plugged. A Carpenter separating calorimeter was used.
>
> It is a fact that the harder a boiler is worked the more water it will discharge with the steam, but the most significant showing of the calorimeter determinations was the presentation of the results as being just the opposite. For example, tests were made on boiler No. 22 under different conditions, with the following results:

Conditions.	Range of moisture, %
Engine L only in service, boiler at small capacity	11.56 to 17.72
Engine L only in service, boiler at large capacity	7.14 to 10.96
Engines L and K in service, taking steam at the same interval, and boiler at full capacity	1.66 to 2.11

> Tests were made under all attainable conditions except that of high water, which was not advisable to attempt. Arrangements were made that the relative crank positions could be made the same, ensuring that these ewo engines took steam simultaneously. The extreme range of all samples, from all boilers, and conditions, was from 1.37 to 23.0% moisture. Moisture with everything in normal condition ranged from 1.37 to 17.72%.

The enormous range last quoted is held to indicate the worthlessness of any single calorimeter determination, and the contrariety of the results given in the short table above, where the calorimeter showed lowest averages when the boilers were under worst conditions, are held to show the unreliability even of averages. Of course, it must be remembered that the above tests apply to a case of heavy water entrainment, where no doubt great variations in water occur in consecutive moments at any given point in the steam pipe. It is not clear that the conclusions have any relation to ordinary cases of fairly dry steam.

In discussion, Mr. A. A. Cary reported how he dealt with some trouble in another form of water-tube boiler. The steam pipe in that case was over the back header; the projection of water backward from the front riser, and a vortex action in the back header, combined to make high water level at the back of the drum, which caused wet steam. A wire cage, such as is used over roof down-spouts, over the back header broke up the vortex action, while the plan of turning the dry-pipe holes *downward* finally secured dry steam. He had studied this case by means of a model, and draws the opinion that models give very exaggerated results, though the *nature* of the actions is well shown. Mr. J. J. Hoppes (Springfield, O.) supported the author's theory that water in steam pipes and spaces tends to drive along the metal surfaces. He had a case of an ordinary horizontal fire-tube boiler where the water tended to creep up the concave surface at the top of the shell and get into the steam pipe. By putting a gutter around the outside of the steam pipe within the boiler, and draining this gutter to the water space, he secured dry steam. The same principle has much importance in its application to separators.

Mr. A. Bement also read a second paper, on "More Exact Methods for Determining the Efficiency of Steam Generating Apparatus." This paper premises that it is important to find separately the efficiencies of boiler and furnace, and suggests that either (1) by supplying a standard amount of heat at a standard temperature, or (2) by operating a boiler at a standard capacity rated by heating surface, it may be possible to obtain comparative figures of efficiency for different boilers. The author cites a comparative test of two closely similar boilers as showing how greatly performances may differ.

One remark in the paper: "The efficiency of any particular boiler is a fixed quantity, which once ascertained according to some standard, applies to any number of reproductions, and thus need only be determined once," brought out much dissent. Prof. William Kent (Syracuse, N. Y.) asserted that the efficiency of a boiler varies with the kind and size of grate and furnace, with the rate of firing, with the kind of fuel used, etc., etc., and any set of standard conditions would therefore mean nothing as to the usefulness of the boiler. Greater efficiency in boiler practice will hardly be attained until firemen are equipped with pyrometers and oxygen-meters as simple as steam gages. Prof. E. A. Hitchcock (Columbus, O.) spoke in the same sense, but suggested that in a properly planned boiler test the heat-balance will show whether the plant is properly handled. Mr. Geo. H. Barrus (Boston, Mass.) held that the paper gives no suggestion of better methods in boiler testing and contains no criticism of present methods. In particular he objected to the author's preference of the term "pure coal" for the present standard term "combustible;" while both terms are open to objections, the latter is least so. Mr. A. A. Cary stated that the present standard method of boiler testing gives complete data for separating boiler and furnace efficiencies, which he illustrated by an example. He also stated that, for determining the efficiency of a furnace which has no boiler connected with it, or for testing a boiler furnace when it is not desired to go to the trouble of a complete boiler test, he has devised a shorter method, which he will describe in a paper before the society. Prof. D. S. Jacobus (Hoboken, N. J.) argued that boiler efficiency is a difficult or impossible quantity to determine. The two principal difficulties are to measure the average temperature of the escaping gases, at the proper point, and to determine the amount of air leaking into the setting.

The last paper that came before the meeting was "The Forcing Capacity of Fire-tube Boilers," by Mr. F. W. Dean (Boston, Mass.). The author begins with the premise that water-tube boilers are generally assumed to have a greater forcing capacity, that is, can be overloaded more, than fire-tube boilers. To controvert this, he exhibits a number of records of tests of fire-tube boilers where the rate of steaming was from 1½ to 2½ times the normal rated capacity. In condensed form these records are:

Items.	Horizontal return tubular. Atlantic Mills, Lawrence, Mass. Two tests.		Horizontal return tubular. Paper Mill, Cumberland Mills, Me. Hand.	Horizontal return tubular. Paper Mill, Cumberland Mills, Me. Stoker.	Manning vertical. Bristol Mfg. Co., New Bedford, Mass.	Manning vertical. Burgess Sulphite Fiber Co., Berlin, N. H. [Roney stoker, draft, 1.28 ins. water.]	Corliss vertical. Narragansett Mills, Fall River, Mass.	Combust type, horizontal. Arlington Mills, Lawrence, Mass.
Water evaporated per pound of dry coal from and at 212 degrees	10.46 lbs.	10.71 lbs.	10.75 lbs.	11.06 lbs.	10.03 lbs.	9.72 lbs.	10.43 lbs.	11.32 lbs.
Water evaporated per pound of combustible from and at 212 degrees	11.18 lbs.	11.57 lbs.	11.53 lbs.	12.06 lbs.	12.00 lbs.	10.48 lbs.	11.27 lbs.	12.47 lbs.
Commercial horse-power	138.7	144.8	630	742	194	562	214	623
Horse-power per square foot of grate	6.37	6.73	12.92	12.00	6.62	10.81	6.41	10.38
Heating surface per horse-power	8.05 sq. ft.	7.70 sq.ft.	6.49 sq.ft.	5.43 sq.ft.	7.13 sq.ft.	4.44 sq.ft.	6.97 sq. ft.	8.51 sq.ft.
Dry coal burned per square foot of grate surface per hour	21.4 lbs.	21.7 lbs.	42.2 lbs.	37.6 lbs.	23.0 lbs.	38.34 lbs.	21.17 lbs.	31.66 lbs.
Dry coal burned per square foot of heating surface per hour	.41 lbs.	.42 lbs.	.51 lbs.	.58 lbs.	.47 lbs.	.78 lbs.	.43 lbs.	.36 lbs.
Water evaporated per square foot of heating surface per hour, from and at 212°	4.30 lbs.	4.49 lbs.	5.39 lbs.	6.35 lbs.	4.83 lbs.	7.76 lbs.	4.83 lbs.	4.05 lbs.

The figures recorded in this summary are not for momentary duty, but for service performed during test periods of from 6 to 24 hours.

The discussion, to which Professors Carpenter and Kent and others contributed, conveyed the general opinion that the impression which Mr. Dean combats does not exist among well-informed men. Prof. Kent cited cases of higher overload service of fire-tube boilers than those presented by the author. He said that high capacity was usually at the expense of economy. Prof. E. A. Hitchcock suggested that locomotive boilers, whose capacity is many times as great as that of stationary boilers in the highest known instances of forcing, and which yet show excellent economy, may owe this combination to the vibration to which they are exposed, the vibration acting to clear the steam-bubbles and thus insure good evaporative action.

RATING OF REFRIGERATING MACHINES.

The technical work of the meeting was concluded by two committee reports. The first was a preliminary report on Standard Tonnage Basis for Refrigeration. This report recommended that capacity of refrigerating machines be measured in tons of ice-melting capacity, taking 288.000 B. T. U. for one ton (2,000 lbs.) of ice-melting capacity. The actual refrigeration produced by a machine is less than this, usually about one-half the ice-melting capacity, because the liquid must be cooled to the freezing point; but taking ice-melting capacity as standard is more satisfactory than any other standard of capacity, and for any given case the actual refrigeration may readily be obtained therefrom.

The second committee report was an addendum by the committee on Standardization of Engines and Dynamos. It recommended that engine-shafts be turned down, beyond the armature seat, by at least 0.006 in., in order to allow the armature to be pressed on more readily.

Both these reports were adopted. The committee on Refrigeration was continued for the purpose of formulating rules for standard tests of refrigerating machines.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering.

Entered at the New York Post-Office as Second-Class Matter.
Published every Thursday
at St. Paul Building, 220 Broadway, New York, by
THE ENGINEERING NEWS PUBLISHING CO.

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 170 SUMMER ST.
ATLANTA OFFICE, AUSTELL BUILDING.

FOREIGN AGENTS.

ARCHIBALD CONSTABLE & CO., LTD., 16 James St., Haymarket, S. W., LONDON.
RUDOLF MOSSE, BERLIN and HAMBURG, GERMANY.
JOHN F. JONES, & CIE. 31 Rue de Faubourg Montmartre, PARIS.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50; 10 weeks, $1.00. To all other countries in the Postal Union: Regular Edition, One Year, $6.00; Thin Paper Edition, One Year, $5.00 (21 shillings). SINGLE COPIES, 15c.

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The field parties on the Panama isthmus are making such good progress that within a couple of months or less, we understand, it will be possible for the Commission to definitely adopt final plans for the construction of the canal. More or less vague reports have been published concerning radical changes in the plans, but the final decision upon such changes is delayed pending the gathering of more complete data.

Many years ago, under the old French regime tentative plans and surveys were made for discharging the flood waters of the Chagres River into the Pacific instead of the Atlantic, by a ten-mile tunnel through the Continental divide. Recent surveys under direction of the present Commission have developed a route by which the discharge into the Pacific can be accomplished by a seven-mile tunnel.

Should this plan for disposing of the Chagres floods be adopted, it will almost certainly lead to a considerable lowering of the Bohio dam and of the canal summit level; and serious consideration is being given to the making of a sea-level canal. Of course such a canal would involve a great addition to the cube of excavation through the long Culebra cut, a distance of some seven miles, and would add largely to the cost and to the time of construction. To offset this there would be saved the large cost for construction, operation and maintenance of the locks required by the plan of the last commission. The final decision of the Commission and its report of the grounds on which its decision is based will be awaited with much interest.

Engineers, contractors and others who may be contemplating work at Panama will be glad to know that the Sanitary Corps which has been operating there has already accomplished a great deal in the way of improving sanitary conditions and lessening the risk of disease. The anti-mosquito brigade has so thoroughly destroyed the breeding places of the mosquito in and about Colon, that the insects are said to be no more numerous there than in New York City during the summer. Yellow fever will doubtless continue to be brought to the Isthmus from time to time, both through cases of disease and through the bringing of infected mosquitos in ships, but the sanitary force, through the maintenance of rigid quarantine and the prompt isolation of cases when discovered, expects to be able to prevent its spread. Complete water supply and sewerage systems are to be built by the Government in both Panama and Colon.

Altogether it would appear that conditions at Panama are to be such that any temperate man in good physical condition who will avoid excesses can go to Panama with no greater risk to life and health than would be involved in a trip to any of the cities in the United States bordering on the Gulf.

A paper read at the annual meeting this week of the American Society of Mechanical Engineers furnishes an excellent illustration of how an elaborate mathematical analysis of the stresses in an engineering structure sometimes serves merely to confirm the work of practical designers who adopt rough and ready rules for proportioning parts.

The paper in question is written by Mr. Sanford A. Moss, of the engineering staff of the General Electric Co., and is entitled: "Influence of the Connecting Rod upon Engine Forces." Mr. Moss gives in his paper a complete mathematical solution of the old problem in connection with the balancing of a steam engine connecting rod, as to how much of its weight should be considered as reciprocating and how much as rotating.

It is apparent, of course, that the end of the connecting rod attached to the crank pin has a purely rotary motion while the opposite end connected to the engine cross-head has a purely reciprocating motion. If it is desired to perfectly balance an engine, how shall this mass, which has a combined rotary and reciprocating motion, be balanced?

The mathematical solution of this problem would probably not be attempted by ninety-nine engineers in a hundred. The problem has been usually solved therefore by assuming that half the weight of the rod is rotating weight and half is reciprocating weight. As long ago as 1852 this rule was laid down by D. K. Clark. The task of making a more exact solution has been left to those with a fondness for complicated mathematics.

Some ten years ago a solution of the problem was made public by R. A. Parke of the Westinghouse Air Brake Co. and his results were embodied in a committee report presented to the Southern & Southwestern Railway Club in 1895. Briefly summarized they were to the effect that the proportion of the rod's weight to be taken as reciprocating varied from 0.512 for a rod 12 times the length of the crank than to 0.569 for a rod 5 times the crank length.

Turning now to Mr. Moss's solution: He states at the end of his mathematical discussion that the fraction of the rod to be taken as reciprocating comes out nearly one-half in all cases and advises that that value be assumed when the radius of gyration of the connecting rod is not known (which it very seldom is). For a closer calculation he states that in an average case the division will be (assuming a symmetrical rod with the two ends of equal weight) about $^{5}/_{18}$ rotating weight and the other $^{10}/_{18}$ reciprocating weight.

It will be noticed that these figures are in substantial agreement with those of Mr. Parke quoted above and Mr. Moss states that they also correspond closely with the results obtained by a German mathematician, Prof. R. Mollier, and made public a year ago.

For the rare cases where it may be desired to make a more exact division between rotating and reciprocating weight than to merely assign half the weight of the rod to each, we set down here Mr. Moss's final formula. It is simply this:

$$\text{rotating portion} = \frac{K^2}{l^2}$$

in which K = the radius of gyration of the rod about an axis through the wrist-pin and l = length of the connecting rod from center of wrist-pin to center of crank-pin.

The remaining weight of the rod is of course the part to be taken as reciprocating.

We deem it well worth while to call attention to this matter because we believe that the importance of good balancing of reciprocating machinery is too much ignored by engineers. It is so simple and easy and inexpensive a matter to balance engines accurately that it ought to receive greater attention.

We have several times recently heard the opinion expressed anent the rapid strides of the steam turbine and the electric motor that the rotary motor is bound to be the motor of the future and the reciprocating type of motor is doomed to disappear. We do not share this belief; but it is certainly true that the reciprocating motor is not made as well as it could be made, and that by giving more attention to the matter of balancing, some of the advantages claimed for the rotary type of motor would be neutralized.

The relative merits of iron and wooden poles for supporting trolley wires have become a bone of contention at Van Wert, O., according to information sent us by a correspondent there. An electric railway is being built through the main street of the town under a franchise which specifies that the poles shall be of iron. The company, however, claims that it cannot procure iron poles before next spring and it desires therefore to obtain permission of the Council to substitute wooden poles. To this change certain property owners are opposed, on the ground that the iron poles are of more pleasing appearance. The main points brought forward by the contending parties are set forth as follows in a local newspaper:

> On the other hand it is pointed out that iron poles are apt to become charged with the dead current from the wires; that should they become charged they would endanger life, and also permit the fluid to escape into the ground and cause the destruction of the water mains and other pipes by electrolysis. Those who support the wooden pole idea are arguing further that they could be made of select timber, turned down smooth, finished and painted so as to be an exact representation of the iron poles. It is also noticed by the supporters of the wooden poles that the company's desire to erect poles of that style is prompted by a wish for expediency only; that the cost of wooden poles is $22 50 each, while those of iron cost $24; that the difference in price would not be material. The opponents of the wooden poles insist that they can be set in concrete or some other non-conductor, and can for a distance of 6 or 8 ft. above the ground be insulated so as to prevent danger to any who might come in contact with them when charged with the current from the wires.

The question whether an iron pole or a wooden pole is the more pleasing in appearance will depend very much on the way the two poles are made and maintained. While it is generally true that iron poles are of neater appearance, it is quite possible to make a wooden pole which will look quite as well as an iron pole and will require less frequent repainting to keep it presentable.

Regarding the relative durability of the two, also, it depends very largely upon what is installed at the outset and how it is maintained. If a pole of durable wood had its butt treated with suitable preservative and was kept well painted, it might easily outlast many of the iron poles now being erected.

Regarding the matter of danger, no very strong argument can be framed against iron poles, since a great number of such poles are in use and accidents from the charging of such poles by defective insulation are very rare. If current leaks into a pole from defective insulation, it has almost invariably an easier passage to earth through the butt of the pole in contact with the ground than would be afforded through the body of any passer-by touching the pole. If the base of the pole is insulated by being set in concrete as is proposed in the extract above printed, the danger from contact with the pole would be greater than if the pole were set directly in the ground, on the other hand, the foot of the pole ought to be set in concrete to preserve it from rapid corrosion and usually is so set. An insulating covering around the base of the pole from the ground level up to a height of 7 ft. or so would certainly be advantageous, both as a protection to pedestrians and a protection against corrosion. We see no reason why a coat of concrete mortar plastered on a wire

lath jacket would not be a cheap and efficient method of protection.

Undoubtedly, with the increasing scarcity of timber, iron poles are to be the ordinary form of construction in the future; but without greater care taken for their preservation their life is likely to be much shorter than is now generally assumed.

In our issue of Nov. 17, we noted in our obituary column the death of Rev. Chas. F. Dowd, and published a statement which was widely circulated in the newspapers at that time, that Mr. Dowd was the originator of the present system of standard time in use on railways and elsewhere throughout the country. A correspondent now calls our attention to the fact (which was already known to members of our editorial staff) that Mr. Dowd was not the originator of the present system of standard time. He was, indeed, the first to propose that railway time should be governed by meridians one hour apart, and this suggestion was made as long ago as 1869, when Mr. Dowd was principal of a young ladies' seminary at Saratoga, N. Y. A number of other persons also reached the conclusion independently and originally that the regulation of time from meridians one hour apart was correct in theory and desirable. Among these persons were Sir Sanford Fleming, Prof. Benjamin Pierce and Dr. Thos. Hill, then President of Harvard University.

Mr. Dowd worked out his proposition in much detail and urged it upon the attention of railway managers from 1869 to 1873. He proposed a general retention of local time, while the difference between local and standard time was to be indicated and marked at all stations by plus or minus signs. Nothing practical came of Mr. Dowd's proposals and the matter of reform in time keeping methods was dropped for some eight years.

In October, 1881, a communication was presented to the General Time Convention, the predecessor of the American Railway Association, by the late Dr. F. A. P. Barnard, Prof. Cleveland Abbe and Prof. Ormond Stone, urging the need of a reform in time keeping. There were at that time over 50 different time standards in use in the United States. By resolution the communication was referred to Mr. W. F. Allen, Secretary of the Convention, who had long been interested in the matter of time-keeping reform through his position as editor of the "Official Guide." In April 1883, Mr. Allen made a report to the Association advocating the adoption of a time reform system which he had worked out in "much detail." It resembled those previously proposed in making even hourly differences but otherwise was quite unlike them; Mr. Allen's familiarity with railway operating conditions enabled him to make provision for the difficulties to be encountered and when he presented his plan to the convention it met with unanimous approval. At the October meetings of the Association, Mr. Allen reported agreements from railways aggregating 78,000 miles to put the system into practical use and the Association by resolution ordered it to be put into effect on Nov. 18, 1883. At the meeting in April, 1884, by formal resolution the Association recognized Mr. Allen as the originator of the system and gave him full credit for his praiseworthy work.

A curious and unexpected result was that after the adoption of the system in the United States, it was extended to foreign countries. In every country in Europe except France and Russia, railway and local clocks are now regulated by the time of the Greenwich meridian or by meridans differing exactly one hour or two hours therefrom. South Africa, Australia, Japan, the Philippines and Porto Rico also base their time reckoning on meridians differing by even hours from that of Greenwich. In Russia the time varies from the even hour by about one minute only. In nearly all parts of the civilized world, therefore, the clocks and watches, if precisely regulated, beat seconds exactly together and their minute hands point to the same figure on the dial, only the hours differ according to the governing meridian.

The following clause relating to the supporting of a pipe sewer, while not out of the ordinary in most respects, merits placing on record:

> The 15-in. pipe sewer, which is to be built through the marsh, shall rest on hemlock plank, 2 × 12 ins. × 16 ft., with two wooden supports under each length of pipe to prevent the weight from resting on the bell of the pipe. These wooden cradles shall be cut out of 6 × 6-in. hemlock and trimmed to fit the outside curve of the pipe. The furnishing and placing of this timber foundation will be considered an extra, for which the contractor will be allowed at the rate of $20 per 1,000 ft. B. M.

It is interesting to compare the foregoing clause with the one designed to meet the same conditions as given in our issue of Sept. 22.

PROPOSED CHANGES IN THE STEAM ENGINEERING FORCE OF THE UNITED STATES NAVY.

The current report of the Chief of the Bureau of Steam Engineering of the United States Navy Department contains some exceedingly pertinent and important recommendations relating to the personnel of the bureau staff and to the greater efficiency of the engineering department of the navy itself. All of these suggestions demand the immediate attention and action of Congress.

Under an antiquated law, in the necessary absence of the Chief of the bureau from his post of duty, his chief clerk becomes the acting chief of bureau, and may be called upon to decide technical questions about which he can have no adequate expert knowledge. This condition is absurd and is unlike the practice in similar bureaus in this and in other countries. Business methods everywhere demand that in the absence of the head of a technical department of any kind, his assistant should also be an expert, especially detailed or appointed for his professional ability and fitted to intelligently and efficiently take the place of his chief during the temporary absence of the latter. The chief of bureau strongly urges the inclusion of an item in the naval appropriation bill detailing an engineer officer of experience as his assistant, with the proper rank and pay; and simple business considerations and the greater efficiency of a very important bureau of the government require that his request should be granted without delay.

In referring to the engineering personnel the report first makes several statements that no one can contest. These are—that a modern navy without an efficient engineering personnel is deficient in one of its prime requisites and will fail in the hour of battle; that no man can become an efficient engineer without the proper training and experience; and that this requisite training and experience can not be obtained by serving for a few months only, and at non-consecutive periods of time, in the engineer department of ships in commission; and finally that present conditions in the steam engineering department of the navy are a cause of grave anxiety to all familiar with the subject.

While this is a direct admission that the law of 1899 abolishing the old steam engineering corps of the U. S. Navy is not working satisfactorily, the context of the report shows that the chief difficulty met with lies in the transition from the old system to the new. The old and experienced engineer officers are passing away; and the line officers now performing engineering duty have not yet had that sufficient experience in their new line of duty which is necessary to impart the confidence in themselves which would alone fit them for duty in the higher grades of the engineering profession. It is now admitted that the chief engineer of a modern warship should not be over 40 years of age, as the strenuous nature of his duties, the high temperatures of his surroundings, the delving into the many almost inaccessible places in such a ship and the grave responsibilities of his office soon tell injuriously upon the average man. And this fact, says the Chief of Bureau in his report, points to a partial solution of the problem.

At the present time only 66 officers are borne upon the navy list for engineering duty only; and as 4 of these retire for age within a year and 7 of the 44 Lieutenant-Commanders will be promoted within the same time, only 37 officers practically remain available for service at sea. As but one-half of this number should be at sea at the same time, we actually have only 19 officers available for this duty. As a matter of fact, the Navy Register of 1904, shows that 11 battleships, 13 cruisers and 4 other vessels, or 28 in all, have each but one engineer officer proper aboard, or 9 in excess of the number which a proper distribution of shore and sea duty among those available would warrant. The engineering departments of the other 62 warships in commission—excluding torpedo craft—are in charge of young line officers or of warrant machinists. The Bureau has nothing but praise for the work performed by these line officers in the engine room of our ships. While they vary in efficiency in this as in other duties, they perform their duties well and only lack consecutive experience and time to make them efficient engineers.

The radical change in the motive power of warships within less than a generation, the total dependence upon steam and electric power, demand that the modern naval officer should be as familiar with these motors and all their details as their predecessors were with sails when sails could alone be depended upon for manoeuvering their ships. This fact is now fully recognized in the training at the Naval Academy, and the engineering course at that institution—which is constantly being extended—warrants the belief that in time our Navy will have a goodly number of competent engineer officers.

But there is an interval to be bridged, and a future to be provided for, and the Chief of Bureau suggests the following means: Granting that the preliminary engineering education is good, it is well known that all officers who rise to prominence in the naval profession do so by reason of continuous study and work after graduation. It is suggested, therefore, that each year a certain number of officers be selected from the line who show an aptitude for engineering, who desire this detail, and who will devote their whole time—ashore and afloat—to engineering. As such a detail would necessarily remove them from command duties in the line, and practically unfit them for command, some compensation must be made for this relinquishment of the greatest ambition of a naval officer. By the system of promotion provided for in the Personnel Bill of 1899, an officer usually reaches command rank at the age of 40; and it has already been stated that a man over 40 years old is unfit for engineering duty at sea. The compensation then to the engineering officer here referred to, says the report, would be: No sea duty after reaching command rank. This plan would require: That all officers of the line be given a sufficient quantity of engineering duty on ships in commission to finally qualify them to take charge of the engineering department of any and all ships. That the class of line officers, now designated as "for engineering duty only" be made permanent; and that this class shall be kept full by selecting each year from the midshipmen who have completed their two years' service at sea, or from among the ensigns, a certain number who shall thereafter devote themselves solely to engineering duty, and shall not perform duty at sea after reaching command rank. That for the immediate future a certain number of officers in the different grades be permitted to request assignment to the list of officers on engineering duty only, and that the fitness of such officers should be determined by an examination prescribed by the Department.

The well known lack of experienced engineer officers to man our navy—which is constantly being added to by new ships—calls for a radical departure from existing practice. The plan of the Chief of Bureau here outlined practically restores the separate steam engineering staff of the old navy, in setting aside certain line officers for a special and restricted duty at sea and on shore. They are still line officers, it is true, and the old element of friction between "Staff and Line" is to that degree removed, especially by the provision that the engineer officer who has obtained command rank leaves the sea for shore duty where he would be less exposed to awkward complications with other line officers of command rank. No one will deny that better engineers will be made available by a system which starts with a personal inclination toward engineering work and gives the opportunity for continuous study and experience in that line of duty. The question is: How many young men, who are properly fitted for a high technical profession, will forego the ambition of every young naval officer—that of supreme command of a ship or a fleet in some future

strenuous event? To-day the duty of the engineer is quite as important as that of any officer on a modern battle-ship, and without his skill and experience the commanding officer and all others are practically powerless—as witness the magnificent record of the Chief Engineer of the "Oregon" in her memorable run from San Francisco to Santiago, in the late Spanish-American War. But will the young cadet—with all the "glory" of a naval career before him, realize the changed conditions of naval warfare, and believe that a station in a hot engine-room, away from the smoke of battle and out of sight of the enemy's ships, is quite as honorable and quite as important to success as a post in a turret or coning tower? This is a condition to be worked out; but meanwhile it is very difficult to suggest any other or better solution for a situation that imperatively demands improvement, than that here laid down by the present Chief of the Bureau of Steam Engineering. Something must be done at once to provide more and better experienced engineer officers; and the only alternative is the placing out of commission a certain number of the ships of our navy, as suggested in the report. This solution every patriotic American would regard as most unfortunate.

LETTERS TO THE EDITOR.

The Stephens Trench Excavator.

Sir: In 1889 while engaged upon the design and construction of an elevator dredge being built by the Bucyrus Co., I was very much impressed with the immense steel buckets necessary for the excavating and conveying of the dredged material, as well as the great power required for operating. I gave the subject considerable thought and study until 1895, when I designed an elevator dredge having attached to the excavating end of the ladder frame a large bucket for cutting the material, and through which an endless chain of small conveying buckets passed for conveying the loose material to the other end of the ladder frame, and thence by chutes to either side. The latter frame was operated by hoisting chains in a similar manner to the dipper arm and bucket of an ordinary steam shovel.

The very interesting excavating machine illustrated on p. 508 of the last issue of your paper is very similar in design, and I hope that you will publish some information of the actual results obtained by the operation of this machine. Yours truly. Robert A. Cummings.

House Bldg., Pittsburg, Pa., Dec. 9, 1904.

Tunnel Driving in Soft Materials.

Sir: The article in your issue of Nov. 10 on the "Remarkable Progress of the Hudson River Tunnel for the New York and Jersey R. R. Co.," together with your editorial comment, was very interesting. Some time ago, if I remember correctly, there was an article in your paper proposing the freezing process in connection with the projected tunnels under the Hudson, and there has been a paper on the freezing process read before the American Society of Civil Engineers. It is difficult to see how the process as outlined in the discussion on that paper can compete with the method of pushing the shield through the silt, as has been done by Mr. Jacobs. As the silt immediately in front of the shield is undoubtedly compacted into a form more or less conical it is probable that boulders of considerable size would be thrown to one side. It is possible that freezing might be an aid in shoving a shield through the piles of a pier or a building, but in the silt of the Hudson River it would take more time and be more expensive. The objection to blasting in removing the frozen material would seem to preclude its use where the rock rises above the bottom of the tunnel for a considerable distance.

The writer regrets that you did not touch on this point in your editorial and is hoping that some of your correspondents may do so. Yours truly, A. B.

New York, Nov. 26, 1904.

(Undoubtedly, where a shield can be shoved by hydraulic pressure right through the material without excavating ahead, as is now being done under the Hudson River, the cost of tunneling should be lower than by any other possible process. But there are extremely few places where tunnels are driven through material soft enough and uniform enough to permit the shield to be thus shoved ahead. The silt under the North River appears to be in a class by itself, so far as tunneling operations are concerned. What is being done in the Hudson River tunnel, therefore, is not likely to be a precedent for tunneling operations elsewhere, and a large field still exists for the freezing process.—Ed.)

Draftsmen and Instrument-Men in the New York Municipal Service.

Sir: Being myself an employee of the Municipal Civil Service, I was greatly interested in the letters of "Skix" and "J. F. S.," printed in to-day's issue of Engineering News, setting forth some of the many shortcomings of the service. I must concur with you in the remarks appended to the letter of "J. F. S." as to the ability of draftsmen to efficiently hold positions as transitmen. Many of these men to whom "J. F. S." refers had been experienced instrument-men before entering the service of the city as draftsmen, but were unable to qualify as such, as no examination for transitman had been held for nearly three years, while there have been several examinations for draftsman during that time.

"J. F. S." also forgets that a great many persons rated as draftsmen in the civil service are doing field work, especially in Queens and Richmond boroughs.

One source of great dissatisfaction among engineering employees is the continual tinkering with the classification and salaries, and I wish to call attention to one very unjust feature in the most recent classification, viz.: the overlapping of the minimum and maximum salaries of the various grades. In this classification the limit of salary for levelers is fixed at $1,200 to $1,500 per annum, and for transitmen at $1,200 to $1,800 per annum. Many employees, holding positions as levelers at salaries of $1,350 and $1,500 per annum, after several years' service in this grade, naturally sought the best means of promotion, and took the recent examination for transitman, and passed high on the list.

They are now being certified for the position of transitman, but are offered only $1,200 per annum, or a reduction of $150 to $300 per annum from their present salaries. Naturally, they decline the appointment, and the Borough President or other appointing official goes down the list till he finds some one, usually not in the civil service, who accepts. As promotion in his own department is generally difficult, owing to lack of vacancies, the leveler, despite several years' service and the fact of passing a good examination, is left without chance of promotion, while an outsider enters a higher grade and is eligible for a higher salary. This injustice would be obviated by simply making the maximum salary in one grade the same as the minimum salary in the next higher grade.

An employee could then enter the next higher grade without suffering a reduction in salary for an indefinite period. Yours respectfully, F. H.

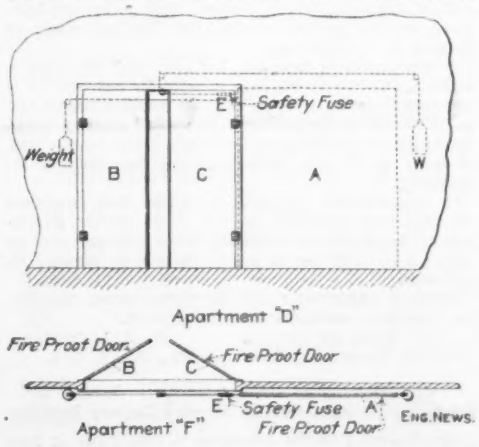
New York, Dec. 8, 1904.

The Requirement of Double Fire Doors.

Sir: May I present a brief answer to "W. T. M.," of Providence, R. I., in your issue of Nov. 10, to correct not only his misunderstanding of the use of double fire doors, but to say a word in support of the methods of insurance inspectors.

Referring to the sketch given by "W. T. M." and here reproduced, he states that with doors B and C partially closed neither heat nor flames would attack the link of door A and cause it to close. If this is the case, it must be evident that the doors B and C serve their purpose admirably, for if heat and flames do not pass through the doorway, being prevented by doors B and C, there is no possibility of damaging apartment F. Now, as a matter of fact, with an intense fire, with doors B and C partially open, both heat and flames would pass by them and would, therefore, reach the link on door A, causing it to close.

Now as to the uses of double fire doors, so called, that is, doors each side of a brick wall at an opening. Experience has shown that in severe fires of long duration



a single fire door is not sufficient, as the wood finally becomes charred and the tin warped sufficiently to allow fire to pass. Under these conditions a second door is needed if an effective cut-off is to be maintained, and it is therefore required in many cases where large values are involved or where it is desired to have maximum safety.

Regarding the chances of a fire starting, this is another side of the question, as the fire doors have to do with a fire after it starts.

In view of the above, is it not reasonable to suggest that the inspector did perhaps use reason and common sense in his recommendations, instead of showing lack of it, as implied by your correspondent? Yours truly,

L. H. Kunhardt.

31 Milk St., Boston, Dec. 8, 1904.

Driving Piles in Dry Ground.

Sir: I have noticed many communications in your journal on the subject of driving piles, and according to my views, they are all theoretical, and practice does not hold good to the theory in any instance, excepting it may be in cases of driving piles in ground covered by water. It all amounts to a matter of judgment at the time the work is being done.

I can show you material, which apparently has never had a drop of moisture in it, which, if disturbed and in contact with moisture, becomes of the consistency of soap and putty combined, yet moisture will not penetrate it in its natural state. When piles are driven into it, it is very difficult to gain depth in it; but after the work is done, and a rain comes on, the moisture follows down the pile to the bottom, and it immediately becomes insecure. When the first great weight comes on the pile, it settles and continues to do so with every additional load which is put upon it, and the natural supposition is that it was not sufficiently driven at the start.

If piles are driven in ground covered by water, then it is possible that some theory might be applied. But if they are driven on dry land and in dry weather, no theory will hold good. I have witnessed the driving of piles in quicksand, with a water jet and steam hammer combined, 33 ft. in the ground and they seemingly could have been driven twice the depth, but for the lack of length, where they could not have been driven 10 ft. by the ordinary process, and yet would have stood every theoretical test of which I have ever heard.

I have witnessed the driving of piles where the inspector was furnished with the most minute formula, and evidently carried out to the letter, but in the passage of the first train after a hard rain, a settlement could be noticed. On the other hand, I have seen piles driven in the toe of the slope of a heavy embankment, which had not been completed 30 days, and the piles did not reach the original surface, and not a particle of settlement was ever observed. While I do not think a pile was ever driven too deep, yet I do persist in the opinion that the question is one of judgment, pure and simple. If the location is one liable to scour then there is more necessity for great depth, even at the risk of "brooming," and the necessity of cutting off above the ground and framing a bent, but to say that there shall be hard and fast rules governing the question, I very much doubt. Piling, like every other structure, should rest on a solid foundation, whether that foundation is gained by the friction of the material surrounding it or by resting on a solid formation which is not likely to be disturbed, it matters not, but there is no rule which will cover both or either.

It is not my intention to treat this question lightly, or as if it were of no importance, and I would be glad to think that there would be a rule found which would overcome the trouble. Especially because as a rule engineers have to leave the inspection of such work to inexperienced men, employed at a salary which will not warrant an experienced man holding the position.

My idea is, after long experience, that the driving of piles, is one of the few items which should never be let by contract; but it should be put in charge of some good reliable foreman, who has had the experience, and is fully acquainted with the results which should be obtained, and make him responsible for results. He would know when and where a long or short drop of the hammer should be used in order to gain the best results, and not be watching the inspector for the signal as to when to stop, and getting rid of the greatest number of piles, in order to get the praise, and possibly extra remuneration from the contractor for whom he is doing the work.

Respectfully yours, P. F. Barr.

Phoenix, Arizona, Nov. 18, 1904.

(The above letter is of particular interest because it refers to the driving of piles in the soil of arid regions, a matter concerning which most engineers know nothing. It is a pretty safe guess that 90% of all the piles used are driven in earth which is either under water or is saturated with water. In fact, unless a pile is below ground water level, it is only a temporary affair, liable to rot out as quickly as an ordinary fence post and wholly unsuited for the support of any permanent structure.

Our correspondent probably has in mind the construction of pile bridges across ravines in the arid region, where the stream is absolutely dry except after an exceptional rainfall when it may carry a huge volume of water. It may well be questioned, however, whether the use of pile foun-

dations in such localities is warranted at the present prices of timber. If engineers in humid regions could have the foundation sites of their structures all laid dry, free of cost and with the soil beneath also free from water, they would have very little use for pile foundations.—Ed.)

Tests on the Shrinkage of Concrete Beams Made at Boston, Mass.

Sir: In your issue of Dec. 1, in reply to a question by Gen. Peter C. Hains, "Why do some concrete walls of great length crack and some do not?" you discuss the shrinkage of concrete in setting and you state that as far as you know no tests have been made on this interesting question.

In the 7th Annual Report of the Boston Transit Commission, for 1901, in Appendix C, there is the record of a test for shrinkage of concrete beams conducted by Mr. H. S. R. McCurdy.

This test was upon two beams of concrete, each 8 × 8 ins. × 8.9 ft., one hardened in air, the other in water. At the end of 12 weeks Mr. McCurdy concluded that the shrinkage would be about 0.028 ft. for a beam 100 ft. long in air and about two-thirds as much for the same length in water. Compensation for changes in length due to changes in temperature was made, using 0.0000075 per foot per 1° F. as the coefficient of expansion. The composition of the concrete is not noted.

This test, though interesting, is too meager to base accurate conclusions on, but the result of the beam hardened in water does not agree with your suggestion that wet concrete may expand as mortar does when hardened in water.

It has been my experience in the New York Subway in concrete arch construction, both in earth and rock, that, unless a sufficient amount of steel in the shape of rods be embedded longitudinally in the concrete to withstand the tensile strains due to contraction from shrinkage and temperature changes, transverse cracks will appear at varying intervals no matter what season of the year the concrete is placed.

I trust Gen. Hains' query will bring to light other and fuller tests upon this interesting and timely subject of the shrinkage of concrete.

Yours truly,
Wilson Fitch Smith,
Assoc. M. Am. Soc. C. E.

36 West 36th St., New York, Dec. 3, 1904.

(Our attention is also called to these same tests by Mr. F. M. Sylvester, and we find upon further examination that these tests were recorded in our issue of Jan. 23, 1902, p. 76. In making the tests on the beams in air, one end was anchored to the masonry of the subway and its free end was so connected with the trunnions of a transit as to cause the transit to revolve with any change in the length of the beam. The transit was directed to a vertical leveling rod, about 240 ft. away, from which readings could be taken. This arrangement magnified the movements of the beam about 3,850 times.

Another correspondent, Mr. Thos. Jenkins, states that the behavior of different walls, as regards cracking, is often dependent upon the character of the cement and its degree of "seasoning" or "cooling." We would remark that cracks due to free lime, or the like, are irregular in shape and position relative to one another, and should not be confounded with vertical cracks due to shrinkage upon setting or due to temperature changes. It is not improbable, however, that the quality of the cement may have an effect upon the amount of shrinkage during hardening. It is certain, moreover, that the coefficient of heat expansion of different stone, used as ballast in concrete, is by no means a constant. In our issue of Oct. 23, 1902, p. 341, will be found a table of heat coefficients of stone and concrete compiled by a member of our editorial staff. From this table it appears that the lowest recorded coefficient is 0.0000033, per 1° F, for a red sandstone, the authority being Thurston; the highest coefficient is 0.0000108, also for a sandstone, the authority being Haswell's pocket-book. Dana is authority for the statement that the Portland sandstone of Connecticut has a heat coefficient of 0.0000096. We call attention now to these facts because experimenters should, in the future, be careful to record not only the proportions of ingredients in concrete, but the physical and mineralogical character of the stone and sand in particular. Experiments may, in fact, demonstrate the desirability of choosing the stone and sand for concrete-steel structures with reference to their coefficient of heat expansion. Limestones and quartzes, thus far tested in concrete, show a coefficient of heat expansion not differing much from 0.000006, the differences being about 10% one way or the other. Neat Portland cement is variously stated as having a coefficient of 0.000006 to 0.000008. Considering the practical importance of an exact knowledge of cement shrinkage coefficients and heat coefficients of both cement and stone, there is remarkably little in print on these subjects. —Ed.)

Sir: The letters of "Ashlar" and of Gen. Haines in your issues of Nov. 17 and Dec. 1, with your comments thereon, induce me to submit a few remarks on the above subject.

It is not clear how "Ashlar" built his wall. Is the stone "slapped up" against the concrete and joined to the latter with ordinary cement mortar, which has no hold on set concrete, two walls being the result? Or are the two run up simultaneously; if so, how?

From Liverpool to Coosaw is a far cry. In the one place we have a damp situation, mild, moist climate and probably, almost certainly, a different kind of cement. I apprehend the same conditions do not obtain on the Coosaw, therefore the results may be expected to differ.

Slag cement is a very patent illustration of this state of things. Under water or in very damp situations its free lime and excess silica will combine and give reasonable satisfaction, but in air silicate of lime is not formed and the added lime remains free, which is not at all desirable.

It seems to me that more attention should be paid to workmanship. What can be expected where the contractor designs, executes and supervises his own work? Engineers and builders do not readily lend themselves to such an arrangement, but some architects seem to like it, probably because it saves them trouble.

As even in "the everlasting" hills, rock disintegration is continuously going on, it is almost too much to say that we can impart indestructible properties to our weaker artificial stone; the most we can do is to apply remedial or protective measures, such as:

Good materials (not over-limed cement and dirty sand); careful supervision of work; not bonding old or set concrete to brick, stone or new concrete work with ordinary cement mortar; not to work in frosty weather; carefully to protect surface for some time from too rapid drying.

When these conditions are observed, a well-laid concrete pavement of considerable area will not crack, but will last until worn out by attrition, and something like the same results may be looked for in vertical work if the same conditions be applied; I admit, however, that this is difficult, but by no means impossible.

Practical concrete workers laugh at expansion joints; they will tell you that their only advantage is in enabling repairs to be made in a more sightly manner. Where irregular patches would have to be put in, they will only disturb one square. If the expansion joint theory is correct, a wall without mortar would be perfection.

What I have seen of cracked concrete work is not so much vertical or horizontal cracks as those of Faience variety; these gradually increase, and then comes trouble. If after a season of exposure such indications are evident, the surface should be washed with annealed or toughened and preferably acid cement, which adheres to the old work and fills up all fissures. If the work settles, or from any cause shows decided cracks, these can be filled up with annealed cement; we may suppose that the limit of contraction has now been reached and any expansion will only press the particles more closely together.

An ounce of prevention is better than a pound of cure, and if disintegration of concrete were taken in hand when its first symptoms appear the ill effects would be reduced to a minimum.

It must never be forgotten, however—as it too often is—that a style of construction suitable for one country is not always to be recommended for another, where climatic conditions are different. One would scarcely think, for instance, of building in concrete in Maine on the same lines as in Florida without making the required allowances.

It is sometimes desirable to render thin reinforced concrete walls watertight as well as to prevent disintegration, but as we can now paint in oils with any color on concrete as easily as on wood, this matter presents no difficulty.

There is undoubtedly a great future before concrete, but canonical conditions must be observed.

Yours respectfully, H. J. Livingston.

43 Post Office Ave., Baltimore, Md., Dec. 6, 1904.

Deadening the Noise from an Elevated Railway Structure.

Sir: Referring to the discussion in your issue of Nov. 17, 1904, relative to a design proposed by me for deadening the noise of the Union Loop, I agree with you perfectly that few engineers are familiar with this subject, and from the nature of your criticisms it does not seem that Engineering News itself is entirely clear. For instance, your reference to the popular and technical meaning of the term "elastic" is incorrect, inasmuch as the exact reverse is true.

In proof I quote from Ganot's "Elementes de Physique," as follows:

Elasticity is the property owing to which bodies resume their original form or volume when the force which altered that form or volume ceases to act. There is a limit to the elasticity of solids beyond which they either break or are incapable of regaining their original form or volume. This is called the limit of elasticity; within this limit all substances are perfectly elastic.

In ordinary life we consider those bodies as highly elastic which, like caoutchouc, undergo considerable change on the application of only a small force. Yet the force of elasticity is greatest in many bodies, such as iron, which do not seem to be very elastic. For by force of elasticity is understood the force with which the displaced particles tend to revert to their original position, and which force is equivalent to that which has brought about the change. Thus the force of elasticity of mercury is greater than that of caoutchouc, glass, wood and stone. It is, however, less than that of the other metals, with the exception of lead.

Having thus fixed the exact meaning of the term elastic, let us see how this is related to sound. Referring again to Ganot, we find the following:

Sound is propagated in all elastic bodies, and the study of sounds and that of the vibrations of elastic bodies forms the province of the science of sounds or acoustics. As a general rule, the elasticity of solids, as compared with their density, is greater than that of liquids, and consequently propagation of sound is far more rapid. . . .

Sound is always the result of rapid oscillations imparted to the molecules of elastic bodies, when the state of equilibrium of these bodies has been disturbed either by a shock or by friction. Such bodies tend to regain their first position of equilibrium, but only reach it after performing on each side of that position very rapid vibratory movements, the amplitude of which quickly decreases.

It is evident then that both the volume of sound given forth by a medium and the velocity of the sound waves in that medium are functions of its elasticity, and the difference in the rate of speed of the sound waves in the various mediums is the one and only means of determining their acoustic properties. Thus we find that the metals, as the most elastic solids, are the best sound conductors and sound producers, and that as the elasticity of bodies decreases so does their sound producing capacity, wood being about three-fourths that of steel; stone, concrete and sand about one-tenth, while caoutchouc is almost nil as a sounding body.

It is readily demonstrated by comparing a bell of metal with one of concrete or wood, that the difference in the sound wave velocity of the different mediums measures the difference not only in the volume of noise, but in its duration. In an elevated structure there are other factors and conditions present, for which reason it is not strictly true that a concrete-steel viaduct is one-tenth as noisy as a steel viaduct, nor have I so claimed it. But as regards the constructive materials in the two structures, there is no ground whatever for the contrary assertion.

As regards resonants, Engineering News seems to forget that there could be no resonant effect without such vibration of the elevated structure as would make it a sounding body. For resonance is nothing more than the vibration of the highly elastic air set up in an enclosed air space by the acoustic vibration of the confining parts. In an elevated railway these parts are the stringers, cross girders and ties, and before the air space they enclose can make itself heard, these parts themselves must acquire sufficient elastic vibration by transmission from the prime vibrators (the rails) to become a factor in the noise.

Further than this, the resonance of the present elevated structure, by reason of the open track construction, latticed stringers and unconfined space generally, is hardly sufficiently perfect to alone explain all the difference in noise observable when a train is running on such a structure than when running on the ground. As a matter of fact, it is only one of many contributing causes. Aside from the sounding property of the metal itself, there is the vibration which passes the limit of sound and is evidenced in motion or in a rattling of the structure as a whole, observable to passengers on the platforms or the trains themselves when standing still while others are passing. There is also the humming of the rails, intensified by their non-continuous support and by the wooden ties, wood being one of the best known resonators and as a tie quite free to act as such. All of these are associated with the structure itself and are independent of the noise due to poor track, bad rail joints and crossings, and to the rolling stock. These are the same, no matter what the structure, and as I have already stated, no remedy can be complete without them. But they require special study and treatment and do not properly enter into the present discussion.

In reference to the muffling effect of snow, this is an example of acoustic reflection and is presented by rain, fog and other natural phenomena, as well as by all substances which are flaky or discontinuous. The reason for this is that such substances contain innumerable reflecting surfaces, each of which reflects the sound wave and weakens it. As they grow denser and more uniform, like snow when it packs or water when it freezes, their reflective power grow less and their sound-deadening effect decreases proportionally. Snow as it packs and freezes also grows more elastic, and the sound it emits on a cold day is familiar to us all. Similar considerations explain the difference in noise between a dirt road and a paved

street, between soft turf and frozen earth, and between a well-ballasted roadbed and a hard earth bed.

It is evident, therefore, that the difference between the noise of a train when running on an elevated railway and when running on the solid ground is due altogether to the elastic nature of the elevated railway structure. Hence my conclusion that the noise will be reduced in proportion as the elastic structure is changed to an inelastic structure. This change is accomplished by the concrete casing proposed first, because, as has been shown, concrete in itself is extremely inelastic; second, because it likewise possesses the property of acoustic reflection; third, because its application greatly increases the mass and general rigidity of the structure; fourth, because as applied it largely prevents the elastic vibration of the rails and the transmission of their vibration to the steelwork; and, lastly, because its inelasticity prevents any appreciable vibration of the enclosed air spaces and so eliminates resonance.

That this is what happens is shown by a type of crossing on the Wabash R. R. which has just come to my notice. In this crossing not only is the floor of concrete and steel, but the main girders as well are concrete, encased in somewhat the same manner as I propose. The result is that whereas in other crossings there is a roaring noise, distinct from the noise of the train, due undoubtedly to the resonance set up by the exposed steel girders, in this crossing there is no difference whatever observable as regards noise between the crossing and the earth fill adjacent.

The concrete casing I propose secures the same result without the disadvantages of the solid floor construction. For instance, it leaves the present situation unchanged as regards obstruction of daylight and disposal of snow. By means of the steel reinforcement the concrete will not only carry the added weight without change in the present steelwork, but will in addition materially strengthen the structure. The converted structure further requires no painting or maintenance and no tie renewals. Concrete-steel girders properly reinforced as these will be deflect less and yield less than steel beams, as proven by frequent tests, and experience has also demonstrated that the concrete does not crack even when exposed to constant and repeated shocks, such as occur in railway structures, factory buildings, etc., and in the driving of concrete pile foundations. The life of the present structure will therefore be increased.

Sand, as suggested by Engineering News, is but little better as a sound deadener than concrete, the difference in the sound wave velocity of the two materials being less than 200 ft. The use of sand would mean a solid floor construction, and from a practical standpoint would be inferior to ordinary ballast. In a solid floor the material between the rails contributes little or nothing to the reduction of the noise, while the solid decking would increase the resonance, and would change the noise to the roaring sound already referred to in grade crossings.

As to initial cost, the greatly increased weight of a solid floor would require strengthening of stringers, cross girders and possibly posts. This would involve most expensive field work, which would run the cost of this construction to an unusually high figure. The concrete casing, on the other hand, would require no alteration of the steelwork whatever, and the method I have devised for applying it largely reduces the cost. From the figures I have made, it appears that the concrete casing would cost considerably less than the solid floor construction, and considering the reduced maintenance as well, it is by no means expensive.

In conclusion I wish to say that the only other adverse criticism the design has received has come from the engineers of the various elevated companies affected, the nature of which criticisms is indicated by Mr. Weston's statement, for instance, that the construction is a "physical impossibility," and by Mr. Menden's that "rubber is more elastic than steel and less noisy." On the other hand, the design has been well spoken of by physicists, experts in concrete steel construction and engineers of prominence, one of these being Mr. Wm. Barclay Parsons, of New York, who says, "a naked steel structure such as our elevated structure, is, as you put it, a most excellent noise producer."

It is undoubtedly true that the proper solution of this problem is not an easy task, but Engineering News has failed to bring home the conviction that it is outside of the pale of engineering. As to the value of my proposal, it is based upon a collection of all the available data and is the result of a careful study of this data and of the local situation. I feel that it deserves to be rated as a definite engineering proposition rather than as a preliminary and immature suggestion.

J. B. Strauss,
Consulting Engineer.

865 Opera House Block, Chicago, Dec. 8, 1904.

Wind Pressures in Tornadoes.

Sir: In your issues of Sept. 1 and Dec. 8, 1904, are described the effects of the tornado of Aug. 20, 1904, upon the Smith Avenue bridge at St. Paul, Minn., and in the latter issue it seems to be shown that a wind-pressure of less than 27 lbs. per sq. ft. may have caused the wreck of part of the bridge.

The present writer has been interested in storm pressures, and in June, 1899, had an opportunity of making an approximation to the least force probable upon a switch-target on the Chicago, St. Paul, Minneapolis & Omaha Ry. at Boardman, Wis., as described in the "Monthly Weather Review" for July, 1899. This target was struck by the tornado of June 12, 1899, which passed up the valley of the Willow River, completely destroying a large portion of the town of New Richmond, killing and injuring several hundreds of people along its course. The severity of this storm was such as to cause the complete destruction of all structures in its path.

The force upon the target necessary to strain the target-rod to incipient bending was about 90 lbs. per sq. ft. As the rod was bent to a considerable angle the wind-pressure must have been much greater, if the target and rod were not struck by flying debris. The writer is of opinion that the rod was bent by the unaided force of the wind, though this could not be shown at the time of the storm. That such pressures are possible in storms of the tornado type is shown by similar calculations of others: see line 16, page 54, "Report of Board of Engineer Officers as to the Maximum Span Practicable for Suspension Bridges" (War Department, Washington, D. C.).

But that the storm of Aug. 20, 1904, at Minneapolis and St. Paul could not compare in intensity with the storms developing the pressures above is conclusively shown by a comparison of the intensities of destructiveness. The writer was within 300 ft. of the church at the corner of 19th St. and Portland Ave., Minneapolis, at the time of the storm. The wreck of this church is shown in your issue of Sept. 1, 1904. At this place the storm was probably as severe as at any point in Minneapolis, though it seems to have been somewhat more severe at places in St. Paul. Now, had the storm developed the intensity of the tornado of June 12, 1899, every building in the vicinity of the church would surely have been leveled to the ground, possibly excepting a few feet of stone or brick walls, though such as there were of these at New Richmond in 1899 were not spared. Hence, as there was no such destruction in the Twin Cities, it is quite possible, or even probable, that the wind-pressure at the Smith Avenue bridge was not *exceedingly* great.

The destructive intensity of tornadoes surely increases at a more rapid rate than does the wind-pressure, owing to accumulation of kinetic energy in the shape of flying debris carried in the air. But this does not vitiate the argument.

Yours truly,
B. F. Groat,
Asst. Prof. of Mechanics and Mathematics,
University of Minnesota.

Minneapolis, Minn., Dec. 10, 1904.

Notes and Queries.

In the paper, entitled "Notes on the Computations of Stream Gagings," which appeared on p. 522 of our last issue, the titles to Figs. 2 and 3 were transposed.

AN EXAMPLE OF FLATTENING OF LARGE CAST-IRON PIPES UNDER EARTH PRESSURE.

By Walter W. Patch.

In designing water distributing systems where cast-iron pipes are to be laid in shallow trenches, it is seldom necessary to consider stresses in the pipes due to weight of the backfilling, since a thickness of metal sufficient to withstand the internal hydrostatic pressure will, in the vast majority of cases, result in pipes of the desired rigidity. There may be instances, however, where pipes of large diameter are placed under high embankments, or in deep trenches, in which the pipe may safely withstand the internal water pressure, but may fail under the loading of the superincumbent earth. It is doubtful if the stresses due to earth pressure under such conditions can be satisfactorily computed, hence to design an economical and safe section recourse must be had to the results of experience in similar cases.

On work under the writer's observation there is a suction main about 850 ft. long, of cast-iron pipe, 48 ins. in diameter and 1.25 ins. in thickness. Straight pipes are in 12-ft. and curves in 6-ft. lengths. These pipes are laid on narrow masonry piers spaced 6 ft. on centers, the piers under the straight pipes being about 2 ft. and 8 ft., respectively, from the bell ends. The pipe trench was excavated through firm earth, or through earth and rock, and was backfilled to the surface, giving from 11 to 23 ft. of covering over the tops of the pipes. Work was completed about three years ago, but the pipe line has not been in use.

A recent inspection showed that in several places a number of adjoining pipes had developed longitudinal cracks for their entire lengths, some pipes having two longitudinal cracks on either side of the invert, with minor connecting transverse cracks in the vicinity of the pier nearest the bell end, while in a few cases there were cracks along the center of the top. Work of removing damaged pipes has been commenced, and both the vertical and horizontal diameters of the remaining pipes have been carefully measured with a vernier rod. The results of these measurements, as tabulated in the accompanying tables, have been averaged between stations 100 ft. apart, as the depth of backfill is fairly uniform between stations, while an average of corresponding diameters for several lengths of pipe minimizes the effect of accidental variations due to lack of perfect symmetry in individual pipes. It may be stated that in the entire pipe line there was no case where the horizontal diameter was found to be less than the vertical diameter. Between Stations 5 and 6 the average depth of fill is given as 8 ft., and the difference between diameters of pipe as 0.028 ft. The backfilling at this point was originally about 22 ft. deep, but it has been reduced to an average of about 8 ft., thus partially relieving the pressure on the pipe.

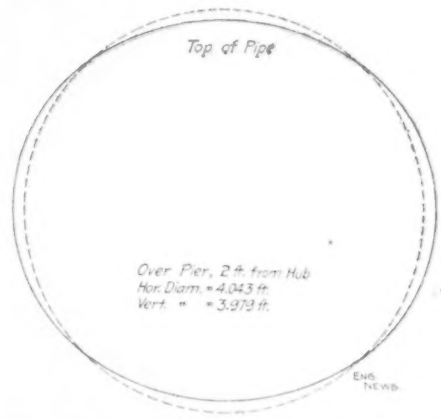


Diagram Showing Distortion of 4-ft. Cast-iron Pipe with 1¼-in. Shell Under a Back-fill of 22 ft.

Deformation along radial lines; scale of distortion about ⅓ full size.

The amount of distortion found in the pipes

Average Diameters of 48-inch Cast Iron Pipes Under Various Depths of Back-filling.

Stations.	Number of pipes measured.	Average depth of back-fill.	Straight pipes 1.25 ins. thick. Section 2 ft. from pier. Hor. Diam.	Vert. Diam.	Difference.	Section at pier. Hor. Diam.	Vert. Diam.	Difference.
			Ft.	Ft.	Ft.	Ft.	Ft.	Ft.
8 to 8 + 50	5	In masonry	4.018	3.974	0.044			
7 to 8	7	22 ft.	4.043	3.947	†0.096	*4.031	*3.966	*0.065
6 to 7	6	23	4.030	3.970	.060	4.039	3.981	.058
5 to 6	7	8	4.012	3.991	.021	4.022	3.999	.023
4 to 5	7	22	4.027	3.972	.055	4.033	3.984	.049
3 to 4	5	18	4.028	3.982	.046	4.032	3.987	.045
2 to 3	8	17	4.024	3.979	.045	4.032	3.981	.051
1 to 2	8	15	4.020	3.984	.036	4.027	3.991	.036
0 to 1	4	13	4.027	3.979	.048	4.035	3.986	.049
			Curved pipes 1.25 ins. thick.					
6 to 7	7	23	4.016	3.978	0.038			
5 to 6	2	22	4.010	3.973	0.037			
0 to 1	13	12	4.004	3.983	0.021			
			Straight pipes 1.25 ins. thick.					
	5	0	4.016	4.007	0.009	Lying on ground.		
	5	0	4.015	4.010	0.005	Upper layer of pipe in pile.		
			Straight pipes 1.50 ins. thick.					
	5	0	4.010	4.014	— 0.004	Lying on ground.		
	5	12	4.026	4.003	+ 0.023	In trench under 12 ft. of earth.		

†Includes one badly cracked length. *Average for four lengths of pipe only.

comprising this suction main was so marked that a comparison was made with some similar pipes in the storage yard. It was found that for pipes lying on the ground, and resting on one line of support, the horizontal diameter averaged 0.009 ft. greater than the vertical diameter; while for pipes resting on other pipes, and having two lines of support 60° apart, the horizontal diameter was only 0.005 ft. greater than the vertical diameter.

Diameters were also taken on some 48-in. iron pipes 1.50 ins. in thickness; and it was found that when lying on the ground the distortion was too slight to overcome the lack of symmetry in the pipes. Some of the same lot of pipes, however, which recently had been laid under 12 ft. of backfilling, showed the horizontal diameter to average 0.023 ft. greater than the vertical diameter.

A number of diagrams have been taken to show graphically the deformation of the pipes. These diagrams were drawn on a small board set up inside the pipe and normal to its axis. The pench was attached to a light wooden tracer arm, which was slotted to run on a brad fastened in the board at the axis of the pipe. As the distance from pencil to end of tracer arm is constant, the resulting diagram, when compared with a circle, will show the deformation along radial lines to full scale.

The accompanying diagram is typical of many taken on sound pipes, and shows plainly by the flattening of the curvature at the bottom the effect of piers in concentrating the load.

SOURCES AND COST OF POWER FOR PUMPING IRRIGATING WATER.

At the Irrigation Congress at El Paso, Tex., in November, 1904, Mr. H. A. Storrs* read a paper with the title given above which we have condensed as follows:

HYDRO-ELECTRIC POWER.—The commercial cost of hydro-electric power generated in the mountains of the arid West and delivered at the pump motor may be as low as 1 ct. per HP.-hour, or about 2¼ cts. per acre-foot of water lifted 1 ft. high. Assuming 3 ft. in depth of water used during the irrigation season and a total lift of 50 ft. electric power delivered at the pumps would cost about $3.40 a year. Commercial rates are generally higher than 1 ct. per HP.-hour, but even 5 cts. is not prohibitive where the lift is not great or only emergency auxiliary supplies are needed or intensive culture is practised.

The actual cost of power delivered to electric motors under favorable local conditions of construction or of combined storage and power works may be less than 1 ct. per HP.-hour. Minimum costs (or charges?—Ed.) may be expected on national irrigation works, "since no interest is charged by the Government on the money advanced for installing the plant" and since profits are eliminated where the owners of the plant and users of power are identical.

POWER FROM COAL.—Western coals may often be procured at low figures, but as a rule they are poorer steam producers than eastern coals. The evaporative power tests of coals now being made at St. Louis by the U. S. Geological Survey will be of great value for western coals, regarding which there is now a lack of data. Commercial tests indicate that 1 lb. of Illinois or Missouri coal will evaporate 7 lbs. of water and 1 lb. of western lignite about 5 lbs., as compared with 10 lbs. evaporated by 1 lb. of Pennsylvania or West Virginia bituminous coal. Western coals have a wide range of character, "Colorado alone producing coals ranging all the way from lignite to anthracite."

For comparative purposes it is assumed that coal costs $3 per ton, that 5 lbs. must be burned per HP. delivered to the boilers per hour, and that pumps, suction and discharge pipes have a combined efficiency of 60%. On this basis the fuel cost per acre-foot per foot lift will be 2 cts. To this must be added 1 ct. for operation, repairs and depreciation, making 3 cts. per acre-foot per foot lift, or $4.50 per acre irrigated per year, with a lift of 50 ft. Obviously, as Mr. Storrs shows in some detail, larger pump units, higher lifts and more efficient pumping machinery will decrease the cost of pumping, as is shown by the experience with Worthington and Riedler pumps on Hawaiian sugar plantations lifting water 100 to 500 ft. as compared with 6½-ft. lifts in Egypt.

POWER FROM CRUDE OIL.—Assuming crude oil of 18,000 heat units per pound, with a thermal efficiency of 25%, then about 1.2 lbs. of oil per HP.-hour would be required. At 90 cts. per bbl. this would cost about 0.4 ct., or nearly 1 ct. per acre-foot per 1 ft. lift, assuming, as before, a pump efficiency of 60%. Adding ½ ct. for labor, repairs and depreciation, the yearly cost of pumping three acre-feet 50 ft. high would be about $2.25 per acre irrigated.

POWER FROM GASOLENE OR KEROSENE.—At 15 cts. per gallon, with other conditions as for crude oil, the fuel cost per acre-foot 1 ft. high would be about 3½ cts., the total cost 4 cts. and the cost per acre irrigated about $6.

ACTUAL COSTS WITH DISTILLED AND CRUDE OIL IN CALIFORNIA.—On this point we quote Mr. Storrs as follows:

> Five engines, rated at 5, 6, 12, 16 and 20 HP., all burning distillate which cost 10 cts. per gallon, cost respectively 4.3, 7.6, 2, 1.1 and 1.9 cts. per acre-foot per foot of lift, for fuel and operation. Two engines, rated at 20 and 22 HP., burning crude oil which cost 3½ cts. per gallon, cost respectively 9 and 8 cts. per acre-foot per foot of lift, for fuel and operation.

PRODUCER GAS AS FUEL.—"Since all internal combustion engines really operate as gas engines," Mr. Storrs says, "it is only a step from oil engines, so-called, to gas engines proper." Probably producer gas would be the best suited and most practicable for irrigation work and it could be economically made from lignites or very poor bituminous coals.

Mr. Storrs presents figures from which he concludes that with coal at $5 a ton, having two-thirds the heat value of anthracite, producer gas could be made which would justify the conclusion stated at the end of the next paragraph.

GENERAL CONCLUSIONS.—Mr. Storrs says that where hydro-electric power is impracticable steam boilers and engines should be selected only for large plants and in localities where fuel, either coal or crude oil, are exceptionally cheap; that, for small plants, internal combustion engines should generally be used, wherever crude oil, distillate, gasolene or kerosene can be obtained at reasonable prices, and that the greatest economy may be expected where crude oil is used; that in the majority of cases, where fuel of some kind must be the source of power, the combination of gas engines with fuel gas producing plants should give the most satisfactory results.

*Electrical and Mechanical Expert, Reclamation Service, U. S. Geological Survey, Chamber of Commerce Building, Denver, Colo.

EXAMINATIONS FOR PANAMA CANAL ENGINEERS are to be held on Jan. 18 at a large number of cities throughout the country. The positions for which an eligible list is desired are the following: Assistant Civil Engineers, $200, $225 and $250 per month. Instrumentmen, $175 per month. Transitmen, $150 per month. Levelmen, $100 to $125 per month. Rodmen, $75 and $83.33 per month. Chainmen, $60 per month. Helpers, $50 per month. Clerks, $75 to $125 per month. Bookkeepers, $75 to $125 per month. Timekeepers, various grades, $50 to $125 per month. Examinations for Surgeons, Physicians, Hospital Internes and Trained Nurses in the Canal service are also to be held on the same date.

Full information regarding the conditions of employment on the Panama Canal Commission were published in our issue of Dec. 8. Candidates for any of the engineering positions should write at once to the U. S. Civil Service Commission, Washington, D. C., for a copy of Circular No. 26, which gives full information respecting the experience, etc., required, the subjects covered by the examination and the plan of marking which will be followed.

THE LARGEST AIR COMPRESSOR IN THE WORLD is claimed to be one in the power plant of the Homestake Mining Co., at Lead, So. Dakota. It is a cross-compound, two-stage machine, with Corliss valves on the steam end, and was built by the Ingersoll-Sergeant Drill Co., of New York city.

The high and low pressure steam cylinders have a diameter of 32 and 60 ins., respectively, the air cylinders are 52¼ and 32¼ ins. in diameter, and the stroke is 72 ins. At rated speed of 50 R. P. M. the free air capacity is 9,000 cu. ft. per minute, this volume being sufficient, under average conditions of mine work, to operate 125 rock drills. The steam pressure is about 130 lbs. The exhaust steam is received by a Wheeler surface condenser, in connection with a cooling tower. The well-known Ingersoll-Sergeant piston inlet valve is used on both high and low-pressure air cylinders, between which a horizontal intercooler is placed in the air circuit. The total weight of this huge compressor with its accessories, is about 400 tons. It is placed beside the great Ellison hoist, the mountain being blasted out to make space for the engine room.

The compressed air produced is used entirely for the supply of drills in the underground workings of the mine, and two smaller machines of the same make, having respective capacities of 2,600 cu. ft. and 4,400 cu. ft. of free air per minute, also supply air for these drills.

Besides these three compressors there are used at the same mine four other air compressors by the same maker, of which one furnishes air at 900 lbs. pressure to charge the storage tanks of a compressed air locomotive, one small machine supplies air to the cylinders which control the starting, stopping, reversing and braking of the Ellison hoisting engine, and two others, with a combined capacity of 2,600 cu. ft. of free air per minute, furnish a general supply of compressed air for various uses in the mills and surface workings.

A SCHERZER ROLLING LIFT BRIDGE having a single leaf of 160 ft. span has just been completed at Cleveland, O., for the Newburg & South Shore Ry. Co. and is the longest single-truss span Scherzer bridge thus far built. The navigation requirements called for a clear channel 120 ft. in width, and as the bridge crosses at a skew of 60° 30' the unusual span of 160 ft. was necessary.

The moving span differs from some of the former railroad Scherzer Rolling Lift bridges in that the operating machinery and electric motors are placed upon the movable span. The pinion at the center of the rolling segment engages with the rack, which is fixed and supported along side of the track girder. This improvement tends to shorten the total length of bridge required and simplifies the machinery and operation. The bridge is designed in accordance with Cooper's Specifications for Steel Railroad Bridges and Viaducts, New and Revised Edition, 1901, to carry two 177½-ton locomotives, followed by a uniform load of 5,000 lbs. per lin. ft. on each track. The operating power provided is composed of two 50-HP. continuous current electric motors, but this large bridge has from the beginning operated so easily that less than 20 HP. are actually used in ordinary weather. The tracks are interlocked with mechanism for locking the bridge so that the operator cannot open the bridge until the proper signals and derailing switches are set to prevent the passage of trains. The entire work was executed under the charge of Mr. H. L. Schuler, Chief Engineer of the Newburg & South Shore Ry. Co.

A LOAD TEST OF A REINFORCED CONCRETE floor was conducted at the Frankford Arsenal, Frankford, Pa., on Sept. 15, 16 and 17 by Mr. James A. Brown, Engineer of the Arsenal. The object was to determine the efficiency of a concrete floor designed in accordance with the Kahn system of reinforced concrete for the Small Arms Ammunition storehouse, now being erected at the Arsenal. This building is to be used as a storehouse for cartridges and other ammunition, and the floor will be called upon to carry a live load of 425 lbs. per sq. ft. As laid out it will be necessary for the girders to support 72,800 lbs. on 19-ft. 3-in. spans. The floor slab is 4½ ins. thick, carried by 12 × 16-in. beams spaced 5 ft. on centers, 16½-ft. span. These beams in turn are supported by 18 × 30-in. girders 19-ft. 3-in. span. The reinforcement throughout consists of Kahn trussed bars. In the bottom of the girders there were 1¼-in. bars which ran full length; there were also two 1¼-in. bars bent up at the one-third points, and there was one 1-in. bar at the center. A 1¼-in. compression bar was placed at the top of the girder at the center. The steel reinfortement for the beams consisted of two 1¼-in. bars running full length, and one ¾-in. bar running half the length of the span. The reinforcement of the slab consisted of ½-in. round rods placed 6 ins. on centers.

The load of pig lead was piled up in rows so as to prevent any arch action occurring. The floor slab and beams were tested first, a full safe load of 425 lbs. per sq. ft. over the entire area causing no perceptible deflection. Loading was continued until the slab carried 162,000 lbs., or 2,000 lbs. per sq. ft. Carrying this loading the beams deflected 11-16-in.

In loading the girders, when a full safe load of 72,800 lbs. had been placed on the platform of the girder the deflection was about 3-32-in. A load of 216,000 lbs., nearly three times the safe live load, merely developed hair cracks. The deflection at this point was about 7-16-in.

A GAS EXPLOSION IN THE BURNETT COAL MINE at Burnett, Wash., Dec. 8, killed 15 miners. At the time of the accident there were 40 men in the mine.

A DRAWBRIDGE ACCIDENT was narrowly averted at Chicago at about 11 p. m., Dec. 6, when an electric car ran onto the Clark St. bridge just as the bridge was opening. Fortunately the bridge tender saw the car and stopped the bridge, the front truck of the car being derailed and the vestibule jammed against the truss. The car stopped with the rear truck on the approach.

ENGINEERING LITERATURE

Supplement to ENGINEERING NEWS. New York, December 15, 1904.

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Is the production of engineering literature gravitating from England to America? Such is the assertion of the London "Contract Journal" in its issue of Nov. 16. In writing of contributions by young men to the "Transactions" of the British Association of Water-Works Engineers the "Contract Journal" states that young men are invited to contribute papers, whereas they might voluntary examine into and record the detail of new departures and experiments, thus filling years of "Transactions." Continuing the "Contract Journal" says:

> Our engineering literature is gravitating to America—a younger nation, where life, energy and enterprise are rampant; where young men read and write, want to make a name, and make it, thus obtaining reputation and dollars by their action.

Young America should heed these kind words of appreciation and try to become even more worthy of them. It is true that many a young engineer has paved his way to success, first, by doing conscientious work in whatever capacity he found himself engaged, second by making careful notes on its essential characteristics and costs, and, third, by presenting the results of those observations to the engineering press and societies in well written form. Ten chances to one it is by recording details which to many may seem unimportant, rather than by attempting more ambitious topics, that recognition will be secured. Young men who show a sure grasp of details are always in demand.

An Old Question.

All stress is divided into three kinds: Tension, Compression, and Shear. So we are taught early in the study of Mechanics of Materials. Of these, the first two are made apparent on every design drawing or "strain-sheet," in the form of figures denoting the absolute amounts of tensile or compressive stress in different parts of the structure. Shear is rarely or never thus noted. It is customary, in connection with such figures, to use the distinguishing signs + and — for tensile and compressive stresses in order to avoid writing out the names themselves. The question is: Shall the positive sign be given to tensile stress or to compressive stress?

The question is old. It has often been discussed, yet practice is not agreed on a uniform method. A correspondent who recently encountered the question brings it before us and suggests that it should not be impossible to secure some general agreement therein. We do not believe there is much prospect of such a result, but it may be profitable to direct present attention to the subject, particularly the attention of the beginner in structural design, who may thereby be led to form a preference for one or the other practice on better grounds than merely because his instructor taught him that way.

We print, below, the letter of our correspondent, together with one or two opinions he has gathered. As an introduction to these we take the liberty of stating the case for each of the two practices. This matter will be old to many of our readers, no doubt, but it will serve to define the question.

Observation shows that most or all of the older structural designers use the *plus* sign to denote *compression*. The practice is not confined to the older men, however, but numbers among its adherents many whose training is not over a dozen years old. On the other hand the *plus* sign is used for *tension* by probably a majority of the more modern or more analytical workers in the field of structures.

The central argument on each side is as follows:

PLUS FOR COMPRESSION.—A structure is an artificial support, carrying certain loads and transmitting their pressures to one or more foundations or abutments. The simplest case is that of a single column; here a load rests on the column and its full amount appears as direct compression in the structure, the pressure being transmitted straight from load to foundation. In the vast majority of cases, structures have the function of supporting a load *above* the foundation, for reasons readily apparent. A structure thus has the main duty of acting as a column, although some of its individual members may be in tension, being used to suspend the foot of one section of column from the top of a second section, or else used to tie together the feet of two battered struts. In any case, compression is the primary stress in the transmission of load down to the foundation. Tension is the secondary form of stress, and, being opposed to the primary form, it should take the negative sign. Thus, take a simple A-frame, or arch of two pieces. Here the load divides, and part of the stress goes down either of the two legs as a simple uniform stress. Now combine this frame with a tie-beam, auxiliary struts and braces, etc., and load it at various points. Each load divides its pressure between the two supports; each component travels by an indirect path from load to support, radiating outward from the load by compression in the struts, and returning by way of tension suspenders to a more direct line between load and support. The compression members are quasi the primary members, and naturally take precedence in the selection of signs for stress. Compressive stress is therefore called positive stress, while the return components of load in the suspenders are properly considered to be negative stresses.

If the synthetical development of structures were based on suspension structures, which it is not, this line of thought would naturally lead to calling tensile stress positive.

A quite distinct consideration is this: Compression members are more bulky, more difficult to design, and have their material less advantageously utilized than tension members. They are usually the designer's first care. The kind of stress which they are subjected to is the important kind, hence is positive stress; tension members are easily handled, are hence a secondary consideration, and take the negative sign for distinction from the important compression members.

PLUS FOR TENSION.—Stress is one phase of a phenomenon of elasticity. All bodies are elastic, and when stressed by the application of a force they are more or less deformed, either temporarily or permanently. Jointed frames, as all trusses and braced structures are ideally assumed to be, experience in their members only longitudinal stresses, tension or compression. The corresponding deformations are also longitudinal, appearing as either increase or decrease of length of the member. Hooke's Law, the fundamental expression of the behavior of elastic bodies, is

$$\frac{\text{Unit Stress}}{\text{Unit Deformation}} = \left\{ \begin{array}{l} \text{A constant, E, called Hooke's Modulus or Modulus of Elasticity or Coefficient of Elasticity.} \end{array} \right.$$

This law, in conjunction with some derived principles, must be employed when it is desired to determine the change of shape of a body or structure under load. In the case of so-called statically indeterminate structures, its use is necessary for the calculation of the stresses in the members of the structure. The calculation of deformations, and the analysis of statically indeterminate structures together form a very important branch of the science of structures. This branch employs algebra extensively and writes Hooke's law thus:

$$\frac{P}{A} \div \frac{\Delta l}{l} = E.$$

In order that this expression may be consistent with ordinary algebraic principles, the two sides of the equation must be equal in sign as well as numerically. Now, E, the modulus of elasticity, is on all accounts a positive quantity. Also A, the cross section, and l, the length of the member in question, are essentially positive in algebraic sense. Note that Δl, the change in length, is a quantity of the same kind as l, being measurel in the same units. The change in length is the difference between the lengths before and after deformation, that is

$$\Delta l = l' - l$$

If the deformation is a stretching, then l' is greater than l, and $l' - l$ is positive. Therefore Δl must be positive in case of stretching. Hence, referring back to the algebraic expression of Hooke's Law, we find it necessary to make P positive in case of tension; the converse necessarily holds true. If we do not act thus, but write P, the stress, negative when it is tension, then our algebraic work is constantly in disagreement as to sign, and we must make constant changes in sign in our analysis. We could avoid this, of course, by considering E, the modulus of elasticity, to be negative quantity, but this seems hardly a reasonable procedure.

With this introduction we present the letter above referred to:

> Sir: I was reading in Trautwine one day casually and noticed that he said minus was the proper sign to use with compressive forces and plus the sign for tension. It happened that all my teaching had been the exact opposite. So I wrote Mr. J. C. Trautwine, Jr., and to-day received the enclosed letters.
>
> Prof. Greene in "Structural Mechanics," 1897, says that because compression tends to increase the sectional area it is proper to use the plus sign, and as tension diminishes the sectional area the minus sign should be used to indicate tension. Prof. L. J. Johnson in his "Statics by Graphic and Algebraic Methods," 1903, tells the students to use the same signs in the same manner. On page 38 of Prof. M. S. Ketchum's "Steel Mill Buildings," 1903, the same notation is advised. Johnson, Bryan and Turneaure adopt the same way of designating the forces in their book "Theory and Practice of Modern Framed Structures."
>
> I have seen it in many other works as well, but was told by a German engineer friend of mine that Germans use plus to signify tension and minus to signify compression. So it may be that to-day many professors are trying to change the old American method and adopt European practice in that respect.
>
> In the school I graduated from in 1887 we had no text book, but the professor taught us personally and gave us authorities so we could hunt matters out. It was research with a vengeance sometimes, and I know all the writers I consulted used the signs as recommended by Johnson. Now, it practically makes little difference which is used so long

as all will agree. If a young fellow is used to one way and works at drawings where the plus and minus signs have a certain significance and then loses his job (as draftsmen do) and gets a job with another company in a few days (as is common) where an entirely opposite significance is given to the signs he will not make a favorable impression on his employer for the first few days if he has some work to tabulate. His employer will not be very lenient with him. It is the habit of men generally to be surprised when run up suddenly against such a thing and to be suspicious of a man who says he has been taught differently from them. It is such a simple little matter and yet one which can easily cause errors to creep into work and has done so, no doubt. A young draftsman in our office ran up against it disastrously on his second job. Yours truly,

M. E. C.

To M. E. C., from John C. Trautwine, Jr.

Upon receipt of your favor of 17th inst., I wrote as per enclosed copy to Prof. Edgar Marburg, Department of Civil Engineering, University of Pennsylvania. Prof. Marburg is, I believe, the Secretary of the American Society for Testing Materials, which is a branch of the International Association for Testing Materials, and I felt that the standard adopted by one or the other of those bodies would naturally have some weight. As you will see, however, from his reply, copy of which I enclose, neither of these bodies has considered the question.

I have always been under the impression that the bulk of modern practice (taking quality into account as well as quantity) was on our side in calling tension plus, or rather I adopted that view for the "Pocket Book" because I thought it in consonance with the concensus of opinion and practice.

I have here a number of strain sheets of the Pencoyd Bridge Works, now part of the American Bridge Co., dated from 1896-1898, in which tension is marked plus. Merriman and Jacoby, in their works on Bridges, also treat of tension as plus, and so does David Molitor, in his paper on the Distortion of Framed Structures, Journal of the Association of Engineering Societies, 1894. On the other hand, Ralph Modjeski, in his designs of 1899, and the Elmira Bridge Co., from drawings received from them in 1900, called tension minus.

One good reason for calling tension plus appears in Mr. Molitor's paper and in Prof. Marburg's instructions to his students to remember that a tensile stress increases (+) the length of a member, and a compressive stress decreases (—) its length. Mr. Molitor's paper deals with the elongations and shortenings produced in the members of a frame by the stresses acting upon them, and it would certainly create great confusion in such matters if a stress increasing the length of a member were called minus. Yours truly,

John C. Trautwine, Jr.

To J. C. T., Jr., from Edgar Marburg.

Dear Mr. Trautwine:

I have your letter of the 19th inst. In my judgment it is a matter of no importance whatever whether the signs — and + be used to express respectively tension and compression or vice versa. It would be well, however, if one or the other designation be universally accepted at least in this country. An academic argument can be made in favor of calling the tensile stress + and the compressive stress — on the ground that in mechanics a force acting away from the origin is called "positive" and one acting towards the origin "negative." Hence, if the center of the joint be considered the origin, a force tending to cause tension in a member will act away from the origin, and may therefore by analogy be called +. These considerations prompted DuBois to reverse his original notation. See also p. 7 of DuBois' "Stresses in Framed Structures," revised edition, 1896. Burr also calls a tensile stress + and a compressive stress —. Johnson uses the opposite notation.

It was formerly the practice at Pencoyd to call a compressive stress — and a tensile stress +, and this is, I believe, the present practice of the American Bridge Company. This is also the practice of the Phoenix Bridge Company. It seems unfortunate, under the circumstances, that Johnson adopted the opposite notation.

In order to easily remember that + stands for tension and — for compression DuBois suggests that the word "compression" contains the letter "m" and "m" stands for minus; while the word "tension" contains the letter "t" which resembles the + sign. I tell my students to remember that a tensile stress increases (+) the length of a member, and a compressive stress decreases (—) its length.

For the opposite notation a + sign may be said to suggest the cross section of a strut (compression) and the — sign a string (tension).

This matter has not been considered by the Int. Assoc. for Testing Materials, nor by the Am. Soc. for Testing Materials.

Very truly yours, Edgar Marburg.

While we do not believe that serious mistakes are liable to arise from the present diversity of practice, the entire matter is submitted for the attention of those interested in uniformity of technical nomenclature.

The Design of Warships.

Reviewed by Amasa Trowbridge,* Ph.B.

WARSHIPS.—A Text-book on the Construction, Protection, Stability, Turning, Etc., of War Vessels. By Edward L. Attwood, M. Inst. N. A., Lecturer in Naval Architecture at the Royal Naval College, Greenwich. London and New York: Longmans, Green & Co. Cloth; 6 × 9 ins.; pp. 300; tables, and 200 figures in the text. $3.

This volume has been written for the use and instruction of those who are interested in any way in the design, building and operation of vessels of war. It treats of such vessels exclusively, merchant vessels being mentioned only to emphasize characteristics which are peculiar to naval vessels. As far as possible the author has treated his subject from a practical standpoint and has introduced only enough of the theory of naval architecture to explain certain points which he mentions in the construction and design of vessels. Because of this practical method of treatment, the book contains a mass of undigested material, such as the thickness of plating for certain portions of the ship and the size of coaling platforms, that would be excellent data for a skilled designer but which might lead an unskilled man very far astray.

The first point considered by the author is the strength of ship. He explains very clearly the method of longitudinal framing, which has been adopted to secure the great strength necessary for large warships. This strength is needed, as he shows, on account of the concentration of the weights of large guns and thick armor. Examples are given to illustrate the difference between the keels required for a short ship and a long ship of about the same displacement, the latter being shallower in proportion to its length.

The examples of framing that are shown include all the general naval types from battleships to torpedo-boats. As the very latest types showing the practically triple hull are given, it is readily seen that great stress is laid on protection from torpedo attacks. It is also apparent, from the same illustrations, that not even the ships of the Royal Navy have any protection from mines, other than the minute subdivision into watertight compartments which is found in all large naval vessels. The framing of first-class cruisers has been treated most thoroughly, and rightly so, for this is the most unsettled type of vessel. Combining as it must, the qualities of a battleship and a fast cruiser, the armored cruiser will always be a source of difference between the engineer and the ordnance officer and the more there is known about this class of vessel, the better it will be for those interested.

In view of the agitation which is going on in this country for simplification in warship design, the elaborate systems for drainage and flooding shown in this book are right to the point. The scheme of an elaborate drainage system has been vigorously attacked as being one of the things which might be dispensed with. Certain it is that the system shown by Mr. Attwood could be considerably simplified and yet be capable of doing all that would be required of it. He has gone into details to quite an extent, thereby showing very plainly what a complicated affair a drainage system has become. He even informs the reader that a book goes with each ship, telling how to pump out any compartment and a specimen page from such a book is given.

One of the most difficult problems that the naval architect has to meet is the ventilation of a ship. This is particularly so in warships on account of the minute subdivision and the numerous bulkheads and decks whose water-tightness must be maintained. In the short chapter devoted to this subject the author has given a very good description of the best methods of ventilation now in use. This is supplemented by an article on automatic ventilation valves, under the general heading of watertight bulkheads. It is to be regretted, however, that more space was not devoted to this important subject. Ventilation systems, like drainage systems, are becoming very complicated and, while they should be made no less efficient, they should be simplified as much as possible.

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In his discussion of "fouling" the author has described in an excellent manner the method employed for sheathing ships to prevent fouling. He gives examples of the two ways of sheathing, either by a double thickness of teak or by a single thickness, as is now practiced. The comparison of speed, horse-power and cost of the Edgar and Apollo classes is extremely interesting. The ships in each class are alike except that some are sheathed and others are not. As the sheathed ships cost $50,000 extra for the Apollo and $75,000 extra for the Edgar class, and in each case were a quarter knot slower for the same horse-power, the comparison shows that sheathing is an expensive way to prevent fouling. Very little is said about the prevention of inside corrosion, although the subject is now being given a great deal of attention by naval architects, and much progress has been made in recent years in the preparation of rustless coatings or cements for this purpose.

Coaling of vessels has been considered only for vessels in still water. The subject of coaling at sea was evidently considered too complex for treatment in such a volume. Very detailed information is given concerning the coaling arrangements of a particular ship. As the ship chosen for illustration is a first class cruiser, the principal points are covered for any ship.

The longest chapter in the book is devoted to "Armor and Deck Protection." The author shows the evolution of the present system of placing armor for battleships and cruisers. He starts with the "Warrior" (1859) and gives the successive steps in the means of protection up to the "King Edward VII" (1902). In the course of his discussion he describes the Harvey and Krupp processes for face-hardening armor. This is done in very few words but plainly enough to give a good idea of either process. Nothing is said, however, that explains the difficulties of manufacture which make this face-hardened steel so enormously expensive in comparison with ordinary steel.

The protection of armored cruisers is treated by showing its development, and figures are given for the size and thickness of the armor of each class from the "Cressy" (1897) to the "Duke of Edinburgh" (1903). The author then shows the way in which the holes in the armored decks are closed to prevent shot from penetrating to the vital parts of the ship. He also explains the method of backing up armor with a wood cushion and the methods of fastening the armor to the ship.

One very interesting comparison is drawn in the relative amounts of armor devoted to protecting the ship and to protecting the guns. Because the guns are useless if the ship is not protected, the latter must be guarded as much as possible and it is shown that in a modern battleship, two-thirds of the armor was for the protection of the ship and one-third for the protection of the guns and men operating them. This is somewhat surprising, as we are accustomed to think of the armor as a fortification principally for protecting the guns and the men behind them, while we see from these figures that twice as much is used for protecting the ship as is used for the guns and gunners.

A statement which the author repeats is perhaps even more surprising. He says that "with modern plates, it has been found that the best results have been obtained with a perfectly rigid support." This is so entirely contrary to the usual opinions which are held as to the best way to stop a shot that the results of some comparative tests would not have been at all out of place. Even the repetition of such a statement does not make as much impression as the thought of trying to stop a 12-in. shot by a rigidly supported piece of armor.

In the chapter on the "Turning of Ships" some very important items which influence the steering are mentioned. The graphical representation of the relative amount of room required for the turning of three different ships, all of about the same length, is very instructive. It brings out clearly the influence of the cut-under bow and stern. It is the lack of such a cut-under bow and stern that makes some of the recent large

schooners which have been built in this country so hard to handle.

It is evident from the arrangement of the book that the author is leading up to the question of warship design. He does so in a logical manner. The first half of the book is devoted to descriptive matter entirely. In the second half, the more scientific questions are considered, but the treatment is made as popular as possible, so that anyone can get a pretty clear idea of the essential points that must be looked out for in new designs. It is a difficult matter to present such a scientific subject in a manner which is intelligible, without the use of a mass of mathematical deductions. Mr. Attwood has done this very neatly and even has the courage to introduce the rolling of ships without first giving a long chapter on the theory of waves. The average reader will not miss anything by the omission of the waves. The resistance and propulsion of ships is treated as simply as seems possible. Froude's Law of Comparison is explained and a method for determining the power required to propel a ship, based on that law, is presented. This is supplemented by an analysis of the distribution of power in ships, to enable one to foretell the total power a new ship would need, including that used by the auxiliaries. In summing up the question of design, the author gives a synopsis of the parts from which a ship is constructed and states how changes in the weight of any of these affect the ship as a whole.

To emphasize some of the points treated in the book the author gives an account of the loss of H. M. S. "Victoria" which was accidentally rammed by the "Camperdown." The sinking of this ship was unquestionably the most severe lesson that could be taught in time of peace. It has led to many changes in construction, however, and was a valuable bit of experience.

On the whole, this book is a welcome addition to naval literature and fills a number of the gaps left by some of the more thoroughly scientific books on naval architecture.

Three Automatic Instruments for Rough Surveys.

Reviewed by H. M. Wilson,* M. Am. Soc. C. E.

AUTOMATIC SURVEYING INSTRUMENTS AND THEIR PRACTICAL USES ON LAND AND WATER.—By Thos. Ferguson, M. Shanghai Soc. Eng. and Arch. With an Introduction by E. Hammer, Professor of Geodesy at the Royal Technical High School, Stuttgart. London: John Bale, Sons & Danielsson. Cloth; 5 × 7½ ins.; pp. 86; 26 illustrations, including a few folding plates. 4 shillings net, or $1.60.

This little volume describes in detail three types of automatic surveying instruments, or rather three variations of the same type, of which the author is the inventor. The reviewer is unacquainted with any other automatic surveying instruments which have been placed on the market and have accomplished the results claimed for these.

Several attempts have been made to develop an instrument which will automatically trace a plan of routes traveled over or which will procure profiles of the same. The author has wisely first described his most successful apparatus, the pedograph, an automatic route tracer for pedestrians. The second chapter is devoted to a description of the cyclograph, or as the name indicates, an automatic route tracer for vehicles. This is his latest production, and at the time of its description had not been fully perfected. The third chapter is devoted to the hodograph, which is self-registering for courses and distances on water. This was evidently the first of the three instruments devised by Mr. Ferguson, is the least useful or automatic, and may be more practically replaced by connecting the cyclograph with the propeller shaft of a boat or with a patent log towed astern.

In his introduction, Dr. Hammer calls attention to the fact that the instruments described are not intended for precise surveying, but are in fact only exploratory instruments by which an itinerary of moderate length and determined by its two extremities may be interpolated between these.

In their present form the instruments are comparatively restricted in their uses, but as this is the first apparently successful attempt at their construction, they may ultimately be modified so as to make them more useful in many kinds of surveying. For topographic surveying their usefulness is restricted, because they are merely route tracers without permitting the automatic indication of crossings of streams, intersections with other roads, the location of houses, etc., all of which are essential. For traversing routes in little known countries, for reconnaissance purposes and for military sketches, these instruments may find a field of utility. They are certainly to be appreciated as a great facility to the traveler who has no acquaintance with the art of surveying. With the pedograph, for instance, a plan of the route traveled can be made as well by an unskilled laborer as by one who possesses skill in the art of surveying. The instrument would thus enable missionaries, planters and others in countries beyond the seas to obtain surveys of routes traveled. Especially worthy of note is the fact that it can be used as well in the dark as in daylight.

The pedograph consists of a U-shaped box, about 12 ins. in either dimension and about 2 or 3 ins. in thickness. In it are suspended two frames, on one of which is stretched a piece of drawing paper, while the other contains a piece of ground glass. The two are kept at a fixed distance by a hinge and lock. Freely moving between these and held by a slight pressure of glass and paper, is a complicated bit of mechanism not unlike the works of a watch, called the recorder. This is kept in a vertical position by a heavy pendulum weight which moves back and forth with each step of the pedestrian. This actuates through a wheel and gearing a sharp-toothed marking wheel which makes a prick in the paper for a given number of paces. By means of pulleys and connecting cords attached to a frame carrying a compass in the top of the box the marking wheel is caused to shift its position for every change of direction of the pedestrian. This is checked by his watching the compass in the top of the box and keeping it, by means of a knob on the side of the box, constantly turned to the north. From the above brief description it is evident that whereas the instrument automatically records on paper the distances as paced, the record of the direction is only semi-automatic, being made by the pedestrian keeping the frame carrying the needle constantly turned in a line parallel with the latter.

It does not seem improbable that sufficient accuracy can be attained to make the instrument useful for many purposes. To extend its use the position of the pedestrian is at all times apparent upon the record and he may thus mark upon the ground glass the course of the drainage, positions of houses, or other facts adjacent to him which may later be transferred to the plan of the route.

The accuracy of this apparatus, being dependent on the accuracy of pacing and the record of direction, the author calls attention to the fact that the former is not dependent upon an exact knowledge of the number of paces made to the mile, but on the uniformity of the pacing. Thus even though the number of paces per mile is inaccurately assumed, provided the pacing be uniform, the plan of the route may be adjusted between known extremities on a general map and reduced or enlarged uniformly to the scale of that map. While errors of azimuth would seem to be great, the author states that errors of closure in many of his surveys with this instrument amount to less than 0.1 per cent. and that without aiming at high precision, the instrument produces a simple meander of any reasonably passable route at the rate of 3½ to 4 miles an hour with a degree of accuracy and rendering of detail which the average plane table or prismatic compass survey could scarcely produce without too great labor.

The more ambitious instrument, the cyclograph, consists of a flat box fixed horizontally to the handle bar of a bicycle. In this is a sheet of drawing paper, kept in constant orientation by adjusting meridian lines ruled on its surface parallel to a compass needle mounted over the box. The progression of the vehicle causes this sheet of paper to be gradually displaced straight to the rear without losing the orientation once given it. A small ink roller presses on the paper a line in the forward trend equal to the backward motion of the paper. The change in direction is recorded by a simple manipulation of the bicycle rider, who turns the paper in azimuth as he progresses so as to retain the parallelism between paper meridians and compass needle. The motive power is derived from a simple eccentric device fixed to the front wheel. The whole apparatus appears quite delicate and complicated, but according to the author is so balanced as to counteract the vibrations of the vehicle. The device is such that the drawing develops visibly as one proceeds and incidental notes of houses, streams, or roads may be indicated on the paper by the cyclist raising the cover to the box and marking the same opposite his position on the plan. A route traversed at the rate of nine miles an hour was thus traced with remarkable fidelity as compared with an instrumental survey of the same.

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THE LONGEVITY OF THE TYPHOID BACILLUS IN WATER.—By E. O. Jordan, H. L. Russell and F. R. Zeit. Reprinted from "The Journal of Infectious Diseases" (Chicago), Vol. I., No. 4, Nov. 5, 1904. Chicago: Printed for private circulation. (Professor Jordan is located at the University of Chicago, and Professor Russell at the University of Wisconsin, Madison, Wis.) Paper; 7 × 9½ ins.; pp. 641-89; map and tables.

The experiments here recorded were made at the request of the Sanitary District of Chicago. An attempt was made to study the longevity of the typhoid bacillus under conditions as nearly as possible like those to which the germ is subjected when discharged with sewage into water. To this end permeable sacs, but retentive of bacteria, were used. The sacs were filled with water taken from the body of water to be studied, then the enclosed water was seeded with the specific germs and the sacs were immersed in the main body of water. The experiments with Lake Michigan water were made in the laboratory, for which purpose tap water was kept running through a receptacle. In the other studies sacs were immersed in the Chicago River, the Chicago Drainage Canal and the Illinois River. The general conclusions drawn from the tests were that "the vast majority of typhoid bacilli introduced into the several waters perished within three to four days."

REPORT OF AN EXAMINATION OF SEWAGE PURIFICATION PLANTS IN OHIO.—Advance Sheets from the Report of the Ohio State Board of Health for 1903. Columbus, O.: C. O. Probst, Secretary. Paper; 6 × 9 ins.; pp. 109; tables, half-tone and other illustrations.

The information here given was collected by the late engineer of the Ohio State Board of Health, Mr. B. H. Flynn, and by Mr. R. Winthrop Pratt, the present engineer. The chemical analyses presented were made under the direction of Mr. E. G. Horton, chemist of the board. The descriptions of plants are based on personal inspections and on information supplied by constructing engineers and officials in charge. Both municipal and institutional works are included. The volume is sure of a general and hearty welcome.

CHICAGO DRAINAGE CANAL TESTIMONY.—State of Missouri vs. State of Illinois and Sanitary District of Chicago. Testimony of John W. Alvord, Consulting Engineer, Chicago, Ill. Chicago: As above. Paper; 6 × 9 ins.; pp. 54.

Mr. Alvord's testimony was for the St. Louis side of this famous controversy, in which St. Louis claims that the sewage of Chicago, as discharged through the drainage canal into the Illinois and Mississippi rivers, is dangerously polluting its water supply. The pamphlet contains some diagrams designed to show the relation between typhoid fever within and outside of Chicago upon the water supply of St. Louis.

AN OUTLINE OF MUNICIPAL GOVERNMENT IN THE CITY OF NEW YORK.—By George Arthur Ingalls, B. A. Albany: Matthew Bender. Paper; 5 × 7 ins.; pp. 79. 75 cts.

The author here presents a concise, well-arranged summary of the government of the City of New York, based on constitutional provisions, general state legislation and the charter of 1901.

A Translation of an Important German Book on Electric Smelting and Refining.

Reviewed by Leonard Waldo.*

ELECTRIC SMELTING AND REFINING.—The Extraction and Treatment of Metals by Means of the Electric Current. By Dr. W. Borchers. Translated from the Third German Edition, with Additions, by Walter G. McMillan, F. I. C., F. C. S., Author of a "Treatise on Electro-Metallurgy." Second English Edition. London: Charles Griffin & Co. Philadelphia: J. B. Lippincott Co. Cloth; 6 × 8½ ins.; pp. 562; four plates and 255 figures in the text. $7.

The third German edition of this important work has its preface dated Aachen, October, 1903, and it is further announced that there is to be an English edition (the book under review.—Ed.), a French edition published by Baudry & Co. and a Spanish edition published by Bailly-Bailliere Hijos, in Madrid. The first English edition was an octavo volume of 416 pages and was published by Griffin in 1897. The present edition of 562 pages has so many changes and additions in comparison with the first edition that it is in many respects a new work.

The book opens with an excellent account of the production of magnesium. The recent exploitation of the alloys of the magnalium class is drawing increased attention to the commercial production of magnesium. It is highly probable that if magnesium could be made in a thoroughly commercial way its use would be enormously extended on account of its great value as a reducing agent. The price of magnesium was 1,500 marks per kilogram or about $165 per lb., in 1865, 380 marks in 1875, 31 marks in 1895, and is now about 5.5 marks per kilogram or 60 cts. per lb.

The good work of our fellow countryman, Henry Y. Castner, is referred to in connection with the production of sodium, but he does not receive due credit for the production of aluminum by the use of sodium.

An excellent resumé of the steps in the electrolytic and electro-metallurgical reduction of aluminum occupies 67 pages. The author attempts the differentiation of the Heroult, Hall and Minet processes and discusses the Bradley patent which has grown so famous because of the recent decision affecting the relation of the Cowles' interests to those of the Pittsburgh Reduction Co. It would have been highly interesting if more could have been written in this section of the book concerning the splendid development of the Hall process at Niagara Falls and other places this side the Atlantic.

The 89 pages devoted to electrolytic copper refining are extremely interesting as giving essentials of European and American practice. These chapters are the best in the book. In regard to the production of zinc, tin, lead and antimony the reader is impressed with the possibilities of replacing all of the old processes using fuels with others making use of cheap water power working through modern dynamos. The elimination of fuels and the great purity which can be economically obtained by electrolytic processes leads one to believe that in Dr. Borchers' chapters we have an outline of the principles which will soon govern the art of smelting and refining.

There is a most excellent account of electrical methods as applied to the metallurgy of silver, gold and iron. The chapters on iron are significant because of the present importance given to the electrical smelting of iron and steel by the appearance of the recent report of the Canadian Government commission appointed to examine this subject.

The induction furnace receives particular attention. Like most European writers, Borchers seems to think that the induction furnace was invented recently in Sweden; whereas substantially the present form of this furnace was invented by an American engineer, Edward A. Colby, whose American patents were issued in 1890 with the somewhat obscure title, "Process of Melting, Refining and Casting Metals." (U. S. patents 428,378 and 428,379 and 428,552.) In the writer's opinion Borchers is quite right in the importance he apparently attaches to this form of furnace. In the induction furnace not only is the thermal efficiency sufficiently high but the complete absence of chemical changes from the effect of electrodes in contact with the furnace charge, and of changes effected by the action of the fuel in the ordinary steel metallury, together with the much less severe service to which the furnace linings and walls are subjected because the heat is generated within the charge itself and does not have to be transmitted through conducting walls, makes the induction furnace of the highest importance. Borchers quotes an output of 44 lbs. of steel per E. HP. per 24 hours by ordinary electrical smelting (Heroult and Stassano) and of 39¾ lbs. by the induction furnace. The steel in the latter case is "tool steel of the very best quality." The question of costs, however, is local and cannot be generally stated without considering individual conditions.

The work as a whole is of the first importance. Its many diagrams and half-tone reproductions, its numerous citations of authority for its statements, and its comprehensive view of the present state of the art, all combine to make the book the most important one we have on this subject, and one which is a monument alike to Dr. Borchers and to the scholarly and lamented translator, Professor McMillan.

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The Best Sculpture.

THE APPRECIATION OF SCULPTURE.—A Handbook. By Russell Sturgis, F. A. I. A., Author of "How to Judge Architecture," etc. New York: The Baker & Taylor Co. Cloth; 6½ × 10 ins.; pp. 235; 64 plates. $1.50, net.

All who have had the pleasure of reading the author's "How to Judge Architecture," reviewed with commendation in this Supplement for March 17, 1904, will heartily welcome this companion volume on sculpture. The general mode of treatment is the same in each volume—that is, the best examples of architecture and of sculpture, arranged by periods, are passed in review, the text being well supplemented by excellent half-tone reproductions of photographs.

The present volume opens with a consideration of "The Greek Standard of Excellence" and continues with a consideration of the later Greek sculpture, that of the Roman Empire and of early Egypt, the European Middle Ages, the Italian revival and decadence, and the French transition. Recent art is examined under the broad classification of form, sentiment, monumental effect, and in comparison with the Greek standard.

Engineering and architecture are closely allied and architecture and sculpture are often inseparable. For these and other reasons the engineer, as such, may advantageously develop an appreciation of sculpture, while the engineer as a man, and particularly as a professional man, will most certainly wish to develop an appreciation of all forms of art. From either point of view this book makes a direct appeal to many of our readers.

State and Provincial Engineering Societies.

INDIANA ENGINEERING SOCIETY.—Proceedings of the Meeting at Indianapolis, January, 1904. Indianapolis: Charles Carroll Brown, Secretary. Paper; 6 × 9 ins.; pp. 226; illustrated. 50 cts.

IOWA ENGINEERING SOCIETY.—Proceedings of the Meeting at Des Moines, January, 1904. Iowa City, Ia.: Arthur J. Cox, Secretary. Paper; 6 × 9 ins.; pp. 156; illustrated. 50 cts.

ASSOCIATION OF ONTARIO LAND SURVEYORS.—Proceedings of the Meeting at Toronto, February, 1904. Toronto, Ont.: Killaly Gamble, Secretary. Paper; 6 × 9 ins.; pp. 179; illustrated. 50 cts.

This year's Indiana Proceedings are unusually good. They include a wide range of subjects, some of which are dealt with in a number of papers. Thus, Messrs. R. P. Woods, J. W. Fulwider and T. B. McMath each has a paper on interurban or urban street railways; Mr. A. Shane has one on the relation of steam and electric railways to each other and to the public; Prof. W. D. Pence treats on railway profiles in relation to the propelling power of steam locomotives and of electric motors, and Prof. W. F. M. Goss writes of locomotive tests, as proposed last January, at the St. Louis Exposition. Other subjects dealt with are central heating stations, steam boilers and engines, chain and chain transmission, ordinary and bituminous macadam, concrete, bridges, the Indianapolis municipal testing laboratory, stream pollution and sewage purification.

The Iowa Proceedings also contain papers on railways: "Recent Railway Progress in Iowa," by Prof. S. N. Williams; "Notes on Railway Construction from the Resident Engineer's Standpoint," by Prof. F. C. French; "The Cedar Rapids, Iowa City & Southern Railway," by J. W. Wardle, and "Electric Power for Railways," by Prof. H. S. Lanphear. Other papers relate to river improvement, flood relief work, masonry design, sewer construction and street intersections. Some cost figures for municipal work in various Iowa cities are given.

The Ontario surveyors, naturally, devote most of their time to various phases and kinds of surveying, but their report also contains matter on drainage, concrete sidewalks, and the railway transition curve. In a paper on "Surveys of Crown Lands in New Ontario," Mr. James Robertson gives some detailed suggestions on camp outfits, food supplies and the like.

In Mr. W. G. McGeorge's paper on "Drainage" we find the following:

> One should be, as far as time and means will permit, a reader of current technical literature. The supplement to the Engineering News on engineering literature is very useful as a guard against buying books that would prove disappointing.

Some interesting extracts from the journal of David Thompson, "fur trader, explorer, astronomer and surveyor," are given by Mr. J. F. Whitson. Thompson entered the service of the Hudson's Bay Co. in 1784, when only 14 years old. He is described by Mr. Whitson as "the discoverer of the course of the Columbia River and the pathfinder of more than one way over the great continental divide." He made numerous surveys and maps, and 45 of his manuscript journals, covering the 66 years from 1744 to 1850, inclusive, are preserved in the vaults of the Surveys Branch of the Crown Lands Department, Toronto.

Industrial Problems in the United States, Great Britain and Germany.

MODERN INDUSTRIALISM.—An Outline of the Industrial Organization as Seen in the History, Industry, and Problems of England, the United States, and Germany. By Frank L. McVey, Ph. D., Professor of Political Economy in the University of Minnesota. New York: D. Appleton & Co. Cloth; 5½ × 8 ins.; pp. 300; folding map and 22 half-tones. $1.50 net.

By choosing three of the most advanced nations of the world and treating them from the historical, industrial and administrative viewpoints Professor McVey has produced an interesting, instructive and suggestive book. To our mind the least satisfactory and possibly the least needed section is the middle one, in which the so-called extractive industries, the transportation, manufacture, forms of industrial organization and commercial institutions of each of the three nations are sketched. For students at school and, in fact, for any one needing to broaden his knowledge of the relative nature and extent of the leading industries of England, Germany and the United States, however, this part may be quite as valuable as the others.

The section on administration (really governmental administration) is differentiated into interference or occasional regulation, systematic regulation and public ownership. Broadly speaking, the United States affords an example of interference, England of systematic regulation and Germany of both systematic regulation of industry in general and government ownership of certain public utilities. In the United States the industrial development is far in advance of governmental administration. Corporations administer the government instead of the reverse. The relative rights and interests of labor and capital still await adjustment, but this is largely true in England and Germany as well.

Plain words are used regarding both the merits and faults of public ownership. The author concludes that it is impossible to say in advance of specific national conditions just where and to what extent the State should interfere, regulate or own. In conclusion the author says:

> In the United States it is clearly demonstrated that we must have stronger political institutions, a sense of duty, and a more enlightened public opinion before we can talk about the enlargement of duties and functions of the state in the management and conduct of industry.

The book is well made, but the half-tones serve little or no useful purpose and detract from the

dignity of the book. The maps, on the other hand, showing by sections the leading products of Germany, the British Isles and the United States, and the trade of the United States with foreign countries, supplement the text and are in harmony with the typography.

The Theory and Practice of Locomotive Operation.

Reviewed by Arthur M. Waitt,* M. Am. Soc. M. E.

LOCOMOTIVE OPERATION.—A Technical and Practical Analysis. By G. R. Henderson, M. Am. Soc. M. E. Chicago: The Railway Age. Cloth; 6 × 9 ins: pp. 536; tables, 5 folding plates and 142 figures in the text. $3.50.

This book will occupy a distinctive place in the technical literature relating to the locomotive, and is destined to be a standard of reference concerning the most advanced theory and practice in the essential principles of locomotive design and operation. Rarely has an author been so fully equipped by temperament, education, capacity for analysis, and practical experience, both as a successful designer and as a supervisor of the maintenance and operation of locomotives. The result has been the production of a book which is at the same time a scientific text book for the technical student and a thoroughly readable analysis and guide for the motive power or operating official of a railway, who wishes to know and take advantage of the salient points of the locomotive as affecting its intelligent and economical operation.

At first glance the non-technical reader may be somewhat dismayed by the quite extensive theoretical discussions, with their accompaniment of algebraic analyses and deduced formulae; but these are in all cases supplemented by numerous diagrams showing graphically, in an exceedingly simple and original manner, the deductions obtained from the theoretical and practical discussions of the various essential features considered. The author's idea and plan in thus combining the mathematical and the graphical is most clearly set forth in the following extract from the preface to the book:

> It has been the author's endeavor to discuss the various laws of mechanics which govern the subject in a technical and practical manner and while formulas are used for the benefit of those who desire to follow entirely through the different phases of the several problems presented, tables and diagrams have been freely introduced to represent graphically the important laws and deductions, so that those who do not care to read the work from a technical standpoint, may obtain all the necessary information on the subject by consulting the diagrams, these having been arranged with a view of providing a ready and convenient reference, so that the varied and complicated problems of locomotive performance may be quickly solved without the aid of extended mathematical deductions.

The book commences with a chapter on Inertia which is followed by one discussing the Steam Action, and then by one that considers Resistance in its various forms, with a natural sequence in the chapters on Slipping, and on Braking. Following the above, are chapters devoted to Steam Capacity, and Hauling Capacity, and the book concludes with two very valuable and important chapters devoted to Water Consumption, and Fuel Consumption.

Under the different topics discussed, the most reliable and valuable matter taken from various competent authorities, contemporary and otherwise, is presented in a manner to save much laborious research by the student, as all of the most important results of investigation in the general field undertaken by the author in this book are presented in concise form and in their proper order. In short, this work of Mr. Henderson's gives in compact form the most up-to-date information as to the state of the art, deduced from leading authorities, as a supplement to a more thorough and advanced development and discussion by the author himself.

In the chapter on Inertia is presented, from a simple elementary beginning, the various forces acting in different directions to accelerate or retard the locomotive while in motion, also the effect of centrifugal force on curves. In this chapter there is given an original method for cheaply and quickly ascertaining the location of the center of gravity of a locomotive relatively to the rails. The effect of inertia on rods and reciprocating parts is discussed at considerable length, the subject of counterbalancing is led up to and considered.

Chapter II., on Steam Action, opens with a simple outline of "what the steam does" and "how it does it" and the resultant changes in the condition of the steam while doing its work. This is followed by reference to losses of pressure in the steam chest, and by a very complete theoretical and practical discussion of valve-motion, which includes in its scope the consideration of the ordinary slide valve, the piston valve, and also double port types of valves. This is naturally followed by a study of the effect of the valve motion on the steam distribution, as illustrated by the indicator card. Compression, effective quantity of steam used and cylinder condensation are each considered in turn. The result of the use of steam in producing rotative force is critically presented, and from that are shown the various strains induced in both the moving and quiescent parts of the locomotive.

Chapter III., dealing with Resistance, considers adhesion, tire wear and its relation to resistance, rolling friction, journal friction and methods which tend to reduce the same. Guide friction, stuffing box friction, and the more important cylinder friction and lubrication are considered. Under valve friction, a collection of valuable data from experiments and tests is given. The elements which make up the total of internal resistance are concluded by a brief reference to link-motion friction. Considerable space has been given to brake-shoe friction and the important influence of center plate and side-bearing friction is clearly brought out. Train resistance is considered in its various elements, such as journal resistance, wind resistance, resistance due to speed, inertia, grade, curves, loading and weather conditions.

Under the title of Slipping, Chapter IV. gives, in a somewhat brief but sufficiently extensive manner, the discussion of the effects of the slipping of driving wheels, including rail friction at starting, and ratio of maximum available tractive force to adhesive weight. Traction increasers are discussed in a very clear manner and their action is illustrated and analyzed at length.

Chapter V., on Braking, gives consideration to the modern types of quick-action brakes and the essential principles of design of a good braking system. The retarding action of brakes is presented, with ample derived calculations and formulae, diagrams and records of tests. The various arrangements of brakes on cars and trucks is shown, and the comparative results are calculated as between inside and outside hung brake-shoes The chapter concludes with the discussion of the so-called "cylinder brake" or compression brake of the Sweeney and Le Chatelier type, in contradistinction to the ordinary friction brake.

Under the title of Steam Capacity there is brought out the vital importance of proper proportions in boiler design in successful locomotive construction for modern requirements of high speed and heavy loads. As bearing upon this subject results are given derived from the extensive tests made by Professor Goss at Purdue University, as well as from a series of tests made by the author of the book on the Chicago & Northwestern Ry.

The preceding chapters are all preliminary to, and lead up to the discussion at some length on Hauling Capacity, given in Chapter VII. This is the all-important element of locomotive operation to the operating department officer of a railway. In this chapter the author presents the theoretical determination of formulae to represent the value of the tractive force at slow, high, and varied speeds, worked out to meet the conditions for simple engines as well as for the leading types of compounds. The application of the deductions are made clear by the use of numerous simple diagrams. Probably no more important feature exists in this valuable book than that referring at considerable length to locomotive rating. This seemingly complex problem has been simplified by Mr. Henderson by means of a readily-understood rating chart or diagram devised jointly by Mr. Henderson and Mr. L. R. Pomeroy, by which an operating official without any technical training can, without making any computations, instantly determine the proper number of loaded or empty cars which can be handled by a locomotive whose tonnage rating is known.

In the chapter on Water Consumption is considered means for obtaining data as to the water consumption either by time or by distance, and under different conditions of service, also means for ascertaining the amount of water per horse power per hour. A careful presentation is given of the benefits of superheating as applied to the locomotive. Reference is made to the use of water scoops, and formulae are worked out for calculating the results to be obtained by their use. Quality of water and the evils arising from impurities are referred to, and consideration is given to the scientific treatment of water to eliminate its objectionable features.

The last chapter, on Fuel Consumption, treats in its first part of the composition of various fuels and the theory of combustion, the thermal value of fuel and its evaporative power. The latter part of the discussion of fuel consumption considers the quantity of fuel used as affected by load, speed, and superheating. In conclusion, on the subject of fuel, valuable information of a thoroughly practical character is given as to the use and the management of oil as fuel, and its advantages and disadvantages.

The outline above will give an idea of the thorough and logical manner in which Mr. Henderson has treated the fundamental principles underlying locomotive operation. This book is one that should have a prominent place in the list of text books for the student of locomotive engineering, and is calculated to be a standard of reference in every well-equipped engineering library. It should also, from its thoroughly practical value, be in the hands of every progressive motive power and operating railway official.

*3 Phillipse Place, Yonkers, N. Y.

A CATALOGUE OF PERIODICAL PUBLICATIONS IN THE LIBRARY OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.—New York: The Society. Paper: 6 × 9 ins; pp. 47.

CATALOGUE OF TRANSACTIONS AND PERIODICALS IN THE LIBRARY OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—New York: The Society. Paper: 6 × 9 ins.; pp. 32.

A CATALOGUE OF PERIODICAL PUBLICATIONS IN THE LIBRARY OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—New York: The Society.. Paper; 6 × 9 ins.; pp. 26.

The simultaneous appearance of these catalogues indicates concerted action on the part of the societies which will soon be housed in the Union Engineering Building. The catalogues show by volume numbers and dates what society proceedings and other periodicals each society has and indicate, either by direct statement or otherwise, the volumes or numbers needed to complete the several files. It is hoped that one result of the catalogues will be the filling of the gaps named.

NATIONAL MOSQUITO EXTERMINATION SOCIETY.—Bulletin No. 1. November, 1904. Henry Clay Weeks, Editor, Bayside, New York. Paper; 6 × 8 ins.; pp. 40.

This society was organized a year ago. The initial number of its bulletin sets forth the objects of and the cash contributions to the society and contains notes on several of the leading workers in the mosquito extermination field. Other efforts to exterminate mosquitos or arouse public sentiment to that end are reviewed. The article by Mr. Henry Clay Weeks, on "Reclamation of the Marshes of New Jersey and Staten Island," which appeared in Engineering News of April 7, 1904, is included as an appendix to the Bulletin.

STATISTICS OF THE RAILWAYS OF THE UNITED STATES for the Year Ending June 30, 1903.—Sixteenth Annual Report Prepared by the Statistician to the Interstate Commerce Commission. Washington, D. C.: Pub. Doc. Cloth; 6 × 9 ins.; pp. 711; many tables and one folding map.

This is the full report of the statistician of the Interstate Commerce Commission, the advance summaries of which were issued some months ago. (Eng. News, July 21, 1904.) The report as compared with previous annual reports, contains no new features so far as the character of the information submitted is concerned. It may also be noted that to permit easy comparison the same general form and order of presentation as prescribed in previous reports is maintained.

A Concise Book on Railway Right-of-Way Surveying.

Reviewed by W. D. Taylor,* M. Am. Soc. C. E.

RAILWAY RIGHT-OF-WAY SURVEYING.—By Albert I. Frye, S. B., M. Am. Soc. C. E. New York: The Engineering News Publishing Co. Cloth; 6¼ × 9¼ ins.; pp. ix + 45. $1.

This little work is very valuable for any engineer who has the work on hand of making a new survey to define the right-of-way boundaries, alinement, gradients, etc., of an old line whose records were inadequately prepared in the first place, or where the records have been lost or improperly kept, or where the increased importance and value of the right-of-way render necessary much fuller and more definite records and monuments than were originally required. The work does not cover all the field that its title might imply, inasmuch as the proper monumenting and outlining of the right-of-way when the railway first takes possession is not considered.

The author conceives his problem to be that of rectifying and defining the notes and alinement of a right-of-way that has been occupied for many years and which usually has become very much more important or valuable then when first laid out. Such right-of-way surveying as is here considered is very important work, and such work becomes more and more necessary as the country expands and cities grow and what was once a right-of-way across an unused woodland or a farmer's field becomes valuable suburban or city terminal property. The only description in many a valuable right of way deed in the West is worded about as follows:

. . . grant, enfeoff and convey to the A. B. Railway Co., a 100-ft. strip of right-of-way, 50 ft. wide on each side of the center line of their railway as now located and surveyed across the S. W. ¼ of the S. E. ¼ of Sec. 30 Township X., Range Y., in Z. County, and containing b acres, more or less.

In later years after many shiftings of the original tracks and after many additional strips have been purchased and some sold a definite survey becomes imperative, especially when great improvements or changes are contemplated, such as track elevation or depression or the construction of terminal yards.

Thus this book is a much needed treatise on a kind of engineering work for which there is already great demand and for which there must be more and more of a demand in the future.

It is to be regretted that the author contented himself with treating only that phase of right-of-way surveying with which his experience has probably made him most familiar. The methods advocated are necessarily so slow and expensive that the use of them would probably not be warranted except where land already has a very high value or where it may reasonably be assumed that it soon will have. It would have been interesting to have the author show how the methods he advocates should be modified where the land values do not warrant the painstaking work he describes. And it would have been instructive to have had some concrete examples given showing the right-of-way width and the cost per mile of such surveys as are advocated.

The general plan of the work has been carefully evolved and the methods suggested are evidently the result of much thought and experience in the line of work considered. The first duty on such a survey is to establish a new "center line" which is to pass as nearly as may be through the center of area at all points and which may or may not coincide with what was formerly considered the "center line." The location of this new center line is to be determined by an ingenious semi-graphical method which gives due weight to all available evidence tending to locate it. Once established, this new center line is to be monumented and referenced at all P. C.'s and all P. T.'s and at as frequent intervals on curves and tangents as may be desirable. Then all boundaries, structures, etc., are to be determined and mapped by a system of rectangular (or Cartesion) co-ordinates from this center line as a base (or "Y" axis). Methods of collecting and indexing the data, of searching for information from deeds and other records, of conducting the field work, of keeping the survey notes, and of monumenting and referencing the new center line and of all important points on the boundaries are fully outlined.

The author thinks that usually two separate and distinct sets of maps should be prepared, one to show the land lines and the other to show structures. The land maps should be on durable mounted white paper which will stand erasing while the structural maps should be made on tracing cloth. Questions concerning the scales to be used in mapping, concerning the compilation of information from old maps and records, and concerning the indexing of the maps after they are completed are fully treated.

An accurate line of levels should be run over the road and permanent and temporary bench marks established as often as may be necessary, the line of levels being preferably referred to sea level by connecting with levels established by the U. S. Coast and Geodetic Survey. Side levels are to be taken to or a little beyond the limits of the right-of-way as often as may be desirable. On the structural maps the position of excavations and embankments and ground elevations are to be shown, also, at all overhead structures, the elevation of the higher rail of each track and the lowest point of vertical clearance.

An appendix contains hints for field work, tables for temperature correction of tapes, a table of allowable errors in levelling, a table of tangents for platting, and trigonometrical formulas.

*Professor of Railway Engineering, University of Wisconsin, Madison, Wis.

A Reference Book of Mechanical Movements.

Reviewed by Chas. R. Pratt,* M. Am. Soc. M. E.

ELEMENTS OF MECHANISM.—By Fe er Schwamb, S. B., Professor of Machine Design, Massachusetts Institute of Technology, and Allyne L. Merrill, S. B., Associate Professor of Mechanism, Massachusetts Institute of Technology. New York: John Wiley & Sons. London: Chapman & Hall. Cloth; 6 × 9 ins.; pp. 264; 341 figures in the text. $2.

This is a reference text book of mechanism. It describes and analyzes about every mechanism or mechanical movement that any engineer would ever have occasion to use, and does so thoroughly and clearly, using as simple mathematics as possible.

In the introduction as well as through the entire book the correct names for all functions are clearly impressed upon the reader, and this alone will be useful knowledge to many engineers who are often at a loss for words to describe their own designs or to discuss those of others.

To enumerate the subjects treated would nearly recite the entire book. In general, it treats of bearings, screws, belting, rope drive, chain drive, cams, linkwork, parallel motions, ratchet wheels, escapements, trains of gears and clockwork, besides which there is a treatise on spur and worm gearing.

In no sense is this a book on machine design, but it is a most valuable reference book to aid the engineer in selecting the proper mechanisms to meet his requirements. The book is well illustrated and has an excellent index.

*Consulting Engineer, 100 Fifth Ave., New York City.

INAUGURATION OF PRESIDENT CHARLES SUMNER HOWE, Case School of Applied Science, Cleveland, May 10 and 11, 1904.—Cleveland, O.: The School. Paper; 7 × 9½ ins.; pp. 63; portrait frontispiece.

Suggestive addresses were made during these inaugural exercises by Mr. W. R. Warner for the trustees of the Case School, by President Ira Remsen, of Johns Hopkins, for the universities in general; by President Henry S. Pritchett, of the Massachusetts Institute of Technology, for the technical schools, by Mr. John R. Freeman, for the technical societies; by President C. F. Thwing, of the Western Reserve University, for the colleges of Ohio. These were followed by an equally suggestive inaugural address by President Howe. Broadly speaking, a pleasing unanimity of opinion was shown as to the need of a more liberal education for engineers than is given at present by the ordinary engineering course, but the principles which should govern in making those changes were uniformly conservative. There are many passages in these addresses well worth quoting. A few have been chosen, and to give them more prominence they have been placed on the editorial page of this Supplement.

JUST PUBLISHED

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Author of "Earthwork and Its Cost."

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"A book of great importance to contractors, written in an attractive manner, presenting a wide range of information as to actual costs of the details of rock excavation."—Dirt Mover.

Table of Contents on Application to

M. C. CLARK Publisher and Bookseller 21 Park Row, NEW YORK

DIMENSIONS OF PIPE, FITTINGS AND VALVES.—Compiled and Arranged for Engineers, Architects and Draftsmen. Also Containing Some Information on Steam Heating, Bathroom Fixtures, Etc. By W. D. Browning. Cleveland, O.: The Draftsman. Flexible cloth; 6 × 9 ins.; pp. 82; table and figures in the text. 50 cts.

Text, diagrams and tables of dimensions are here combined to save draftsmen the time and trouble of referring to numerous sources of information or, in some cases, of working up information for their own use. In some instances poor cuts from trade catalogues are used where line drawings would be far more serviceable. No joints of cast-iron pipe or of sewer pipe are shown.

A STATISTICAL ACCOUNT OF AUSTRALIA AND NEW ZEALAND, 1902-3.—By T. A. Coghlan, Chief Statistician. Tenth issue. Published by authority of the Government of New South Wales and the Commonwealth of Australia. Sydney, New South Wales: Pub Doc. Boards; 5⅛ × 8⅛ ins.; pp. 967; tables.

This comprehensive and exhaustive publication follows the general lines laid down in previous editions already reviewed in this journal. A variety of statistical and descriptive information is given for each of the Australian States, the new Commonwealth is described, and the constitutions of both the Commonwealth and the States composing it are given. There are sections on local government, food supplies and the cost of living, land and settlement, railways and like subjects. The volume also contains an interesting review of industrial legislation in Australia.

THIS NEW AND PRACTICAL BOOK IS NOW READY

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THE ENGINEERING NEWS PUBLISHING CO.
220 BROADWAY, NEW YORK

Major Dutton on Earthquakes.

EARTHQUAKES IN THE LIGHT OF THE NEW SEISMOLOGY.—By Clarence Edward Dutton, Major U. S. A., Author of "The High Plateau of Utah," "Hawaiian Volcanoes," "The Charleston Earthquake," etc. New York: G. P. Putnam's Sons. London: John Murray. Cloth; 8¼ × 5¾ ins.; pp. xxiii. + 314; 10 plates and 63 figures in the text. $2 net.

Major Dutton, who has devoted years to the close study of the geologic forces in nature, in the present volume treats of the scientific investigation of earthquakes as developed since 1870. Prior to that date, as he notes in his preface, the published studies upon this subject were little more than narratives of disaster with scarcely any attempt at arriving at causes or drawing conclusions. Then, earthquakes were simply classed among the formative forces in nature, mysterious in origin but capable of accomplishing important structural results and of vastly changing conditions in the earth's crust. The new seismology, developed by John Milne and his followers, is scientific in the strictest sense; it investigates the phenomena of earth movements by means of the most delicate instruments which measure and record force and direction of motion, speed and acceleration; this investigation falls within the great department of physics in its treatment of elasticity and wave-motion. The new science deals with earthquakes as the effects of geologic forces, as the elastic vibration of the earth-mass.

The chapter generally discussing the cause of earthquakes notes two of these causes, apparently quite distinct, but possibly interrelated. The one cause is volcanic; the other is tectonic, or having its origin in a force which is presumed to be always active in disturbing the rocks which form the outer shells of the earth. To the last group belong such phenomena as the elevation or depression of surface areas, the falling or shearing of strata, or in fact, the effects of any effort of nature to restore disturbed equilibrium in sections of the earth's crust.

Chapters V. and VI. describe in detail the more important instruments used in seismometry; and Chapter VII. discusses seismic vibratory motion and explains the four kinds of wave-motion with which the inquiry deals. Of these waves, two kinds—the normal and transverse—pass through the earth-mass; the third, not yet fully understood by investigators, travels along great circles around the earth; and the fourth is ascribed to secondary effects of other vibrations. Succeeding chapters deal with the intensity of motion, variations of intensity as a means of computing the depth of origin of an earthquake when sufficient data are available, the speed of propagation, earthquake distribution, etc. A final and very interesting chapter is devoted to sea-quakes and the discovery of several regions of great seismic activity in the ocean.

An effort has been made to bring the subject of earthquakes within the range of popular science, by simplifying the terms used and by generally avoiding mathematical forms. But its value lies in clearly showing the scope of the newer scientific investigation of these phenomena and the steps taken towards deducing conclusions so soon as sufficient intelligent data are available for this purpose.

BULLETIN OF THE BUREAU OF STANDARDS.—Vol. 1, No. 1, issued Nov. 1, 1904. Washington, D. C.: Department of Commerce and Labor, Bureau of Standards. Paper; 7 × 10 ins.; pp. 124; several plates and numerous illustrations in the text.

This first issue of a regular scientific publication by the Bureau of Standards is accompanied by the following prefatory announcement by Director S. W. Stratton:

The Bulletin of the Bureau of Standards, of which this is the initial number, will embody the results of its investigations, researches, and other work which may be of prominence to the scientific, technical and manufacturing interests of the country. It will be issued at intervals as frequently as the number of papers ready for publication may require.

The Bureau of Standards, it will be recalled, is the successor of the office of Standard Weights and Measures, the change taking place in 1901. The scope of the new Bureau is much wider than that of the office, and it will be, when fully developed, a physical standards laboratory of rank with those at Paris, Berlin and elsewhere.

The table of contents of this first issue of the Bulletin is: "The Comparison of the United States Prototype Meter," by Mr. L. A. Fischer; "A Study of the Silver Voltameter," by Mr. K. E. Guthe; "The So-called International Electrical Units," by Mr. F. A. Wolff; "The Spectra of Mixed Gases," and, "On Secondary Spectra and the Conditions Under Which They May Be Produced," and "Some New Rectifying Effects in Conducting Gases," by Mr. P. G. Nutting; "On Fibers Resembling Quartz in Their Elastic Properties," by Mr. K. E. Guthe; "On the Temperature of the Arc," by Mr. C. W. Waidner and Mr. G. E. Burgess.

NOTES ON HYDROLOGY, and the Application of Its Laws to the Problems of Hydraulic Engineering.—By Daniel W. Mead, M. Am. Soc. C. E., Consulting Engineer; Professor of Hydraulic and Sanitary Engineering, University of Wisconsin. Chicago: The Author. Cloth; 6 × 9 ins.; pp. 202; 43 tables, 46 diagrams and 19 maps. $2.

In preparing an initial program for his classes, Professor Mead was confronted by the fact that while there was an extensive volume of literature on hydraulic engineering there was no single simple treatise dealing with its fundamental principles. He therefore commenced to block out notes and information for the use of his classes, and as the matter developed he eventually concluded to put the work in book form.

After a brief presentation of the meaning and scope of hydrology, or "the science of water," the description of water and its properties is taken up, together with its agricultural, commercial and sanitary relations. Two short chapters deal with hydrography and hydro-meteorology, and are followed by a long chapter on hydro-geology, showing the relations of geology to water supply and describing conditions which obtain in the United States. Other chapters deal with the physiography and rainfall of the United States, and are accompanied by numerous maps, diagrams and tables. Stream flow, ground water and surface waters are next discussed and are followed by a chapter on the measurement of flowing water. Ice influences and the chemistry of natural waters are treated, and the book closes with an outline of the application of the principles of hydrology to practical purposes.

The book is illustrated with diagrams and maps and contains numerous tables, selected from various sources, which are duly acknowledged. A valuable feature is the bibliography appended to each chapter. Some of these bibliographies contain a large number of references. The exigencies of hasty preparation and publication, arising from the short time between Professor Mead's recent appointment and the opening of the collegiate year, explain the lack of uniformity in the illustrations and the relatively scanty treatment of some divisions of the subject. A number of the illustrations suffer from over-reduction or from not having been properly drawn and lettered for the reduction used. Not all the data presented are recent. There is no index. "Watershed" appears to be used throughout where drainage area would be more correct.

For its primary purpose, a hand-book for his own students, these "Notes on Hydrology" will doubtless be very serviceable. They contain much useful information in convenient form for practicing engineers, and they might readily be perfected and expanded to serve as a general text and reference book on hydrology.

BUILDERS' HOISTING MACHINERY.—Simple Lifting Tackle; Winches; Crabs; Cranes, Travelers; Motive Power for Hoisting Machinery. Edited by Paul N. Hasluck. London and New York: Cassell & Co., Ltd. Cloth; 4 × 7 ins.; pp. viii + 96; 83 figures in the text. 40 cts.

This little manual is divided into five chapters: I, Simple Lifting Tackle; II, Hand Crabs and Winches; III, Traveling Crabs, Hand and Power; Cranes and Traveling Crabs; IV, Applying Motive Power to Hoisting Machinery.

Although an author's statement is made to the contrary, the book is more fitted for the designer of hoisting machinery than for the purchaser and user. However, the book does not go into sufficient detail to satisfy the wants of a designer, although it may offer some suggestion. The manual is a compilation from articles that have appeared in the "Building World," and, as these

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articles have been written with a view to be intelligible to anyone possessing little or no technical education, too much should not be expected by the designer. On the other hand, we fear that the American user of crabs and cranes will find little enough to guide him.

Three Books on Mechanical Drawing.

ELEMENTS OF MECHANICAL DRAWING.—The Use of Instruments; Theory of Projection and Its Application to Practice; and Numerous Problems Involving Both Theory and Practice. By Gardner C. Anthony, M. Am. Soc. M. E., Professor of Drawing in Tufts College and Dean of the Department of Engineering; Author of "Machine Drawing" and "The Essentials of Gearing." Revised and Enlarged Edition. Boston: D. C. Heath & Co. Cloth; 8 x 6 ins.; pp. 152; 196 figures in the text, besides many figures accompanying problems. $1.50.

ELEMENTS OF MECHANICAL DRAWING.—Their Application and a Course in Mechanical Drawing for Engineering Students. By Alpha Pierce Jamison, M. E., Assistant Professor of Mechanical Drawing in Purdue University. New York: John Wiley & Sons. London: Chapman & Hall, Limited. Cloth; 6 x 9 ins.; pp. 226; 57 plates and 82 figures in the text. $2.50

ELEMENTS OF GENERAL DRAFTING FOR MECHANICAL ENGINEERS.—By C. E. Coolidge, Assistant Professor of Machine Design, Sibley College, Cornell University, and H. L. Freeman, Instructor in Machine Design, Sibley College. New York: John Wiley & Sons. London: Chapman & Hall. Cloth; 12 x 9 ins.; pp. 51; 21 folding plates, 49 figures in the text, and pocket for additional loose illustrations. $2.50.

A commendable feature of Professor Anthony's book is the placing of all cuts on the same page or the page opposite the text. The text is terse and clear, but some of the drawings suffer through the small size required for so small a page. The originals of some of the working drawings might have been executed in better form.

After discussing instruments and their use the author takes up geometrical problems, conic sections, orthographic, isometric and oblique projections, the development and intersection of surfaces, spirals, helices and various practical examples and problems.

In finishing drawings the author recommends that the pencilled construction lines be left untouched—neither inked nor erased—so that the methods and reasoning of the student can be followed. The wax-engraved illustrations are well executed, and what is more, very well printed.

Professor Jamison's book is more comprehensive than the one just noticed, but the illustrations are not so well placed in relation to the text.

The opening chapter is devoted to the principles of mechinical drawing and the next chapter to lettering. There follow orthographic projection, drawing tools and materials, the reproduction of drawings by blue printing, photography and hectography. Next comes patent office drawings.

Color work, either by plain wash (tinting) or by stipple is interestingly discussed. Some of the half-tone reproductions of such exercises show up very well. The chapter on "Sketching" is rather meager. Under "Mechanical Execution of Drawings," some good, some indifferent and some very poor examples of the art are presented.

Some of the shading employed is open to criticism. The wax-engraving process is perhaps responsible for the objections which might be raised against the character of some of the illustrations. In general, the mechanical make-up of the book is good.

The third of these books is designed more particularly for students of mechanical engineering and carries the student further in practical work than do the others. The originals of the illustrations in the text were better executed than those for the more complicated drawings reproduced on the plates, but as the latter are working drawings perhaps rough execution may be excused; perhaps, also, the wax-process is responsible for some of the poor features of these illustrations.

The book is in three parts, the first of which outlines five courses in drawing: (1) Elementary Principles; (2) Working Drawings, from sketches of machine parts; (3) Assembly Drawings; (4) Details and Copies of Working Drawings; (5) Foundation Drawings, Floor Plans and Patent Office Drawings. The second part of the book describes the selection, use and care of instruments in detail. In the third part the essentials of technic employed in the execution of a completed drawing are given.

Builder's Hardware.

LOCKS AND BUILDERS' HARDWARE.—A Hand-Book for Architects. By Henry R. Towne, Past Pres. Am. Soc. M. E.; President The Yale & Towne Manufacturing Co. New York: John Wiley & Sons. London: Chapman & Hall. Leather; 4 x 7 ins.; pp. 1117; many illustrations. $3.

The reviewer approaches the estimation of this book with mixed feelings. Perhaps the term idealized trade catalogue would come nearest explaining the impression it conveys did this term not imply a belittlement which the book does not deserve. This is not because of the lavishness displayed in its production, for lavishness in trade catalogues is not new, but because the author has woven in with the usual trade catalogue matter a brilliant woof of discussion on the technical and artistic features of lock-making that must be classed as work of a higher order and of exceeding interest. This characteristic coupled with the moderate price of the book should place it in the hands of architects and builders generally, even though one hardware manufacturer's product is illustrated to the practical exclusion of the work of others.

The subject of the book is builders' hardware, a somewhat elastic term whose meaning is sufficiently familiar to need no further explanation. The treatment of the subject is divided into ten "parts," which are of varying importance and interest. To the general reader the three parts on history and general discussion, on the mechanics of hardware and on art metalwork and ornament will prove the most interesting and enlightening. For the architect and builder, who uses the book in making his designs and bills of material, the section on specifications and those illustrating, describing and pricing locks and plain and ornamental articles of miscellaneous hardware will probably be the parts most frequently consulted. These last-mentioned portions constitute the handbook features of the volume and might easily stand alone. Of their completeness and accuracy we can only judge by supposition; they are voluminous and they have been prepared by one whom long experience and exceptional talents have rendered familiar with his work. On the other hand, the information is limited to the products of a single manufacturer. This stricture does not apply to the discussions of more general character that have been cited. The rules of artistic design and mechanical construction are of general application, and the treatment of these features may properly be outlined at more length.

Referring first to the opening section of the book, which the author labels narrative and historical, we find a number of chapters devoted to a discursive account of the historical development of the locksmith's art, a chapter on the work of Mr. Linus Yale and a chapter on the growth of the Yale & Towne Mfg. Co.'s works. The two chapters of most value are that on the mechanics of the Yale lock and that on the growth of artistic design in builders' hardware.

The portion of the book that is likely to be of most real value to the student of lock-mechanicism is that entitled "The Mechanics of Hardware," occupying some 130 pages and analyzing and describing in detail the mechanism of locks of all kinds and of window fastenings, trim for

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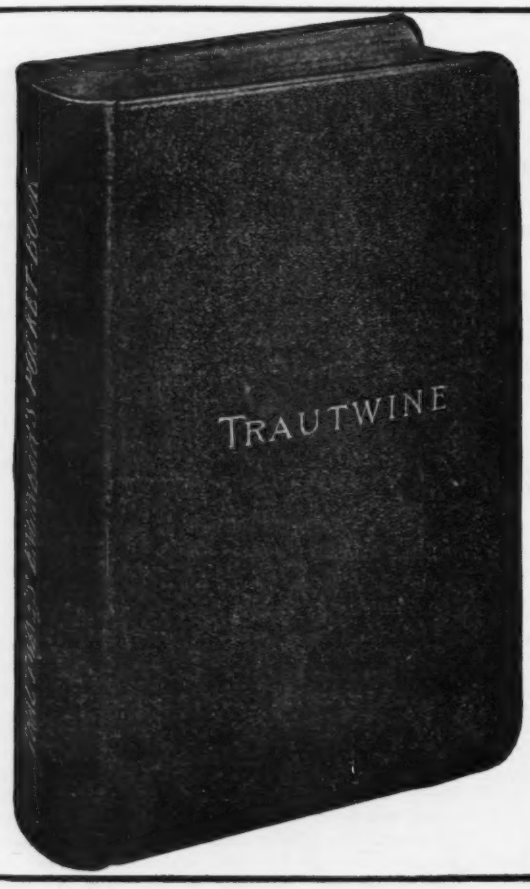

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all purposes, butts, hinges, bolts, door springs, etc. It can be truly said that each and every one of the 35 sections of this part is of exceptional interest and value.

To the designer of art metalwork or builders' hardware the most valuable portion of the book will doubtless be the 308 pages on "Schools of Ornament," contributed by Mr. W. W.* Kent. Each "school" is considered separately and its characteristic work illustrated by numerous half-tones showing ornamental carvings, vases, jewelry, metalwork, etc., etc. A concluding page or two of many sections contain illustrations of modern hardware designed on the basis of the particular school being considered.

In concluding this notice mention should be made of the lavish illustration of the book. Altogether there must be some thousands of illustrations in half-tone and line drawing. This feature alone makes the volume an exceedingly valuable source of reference to the architect and builder.

A New English Edition of Chatelier-Boudouard's High Temperature Measurements.

Reviewed by Wm. Kent,* M. Am. Soc. M. E.

HIGH-TEMPERATURE MEASUREMENTS.—By H. Le Chatelier, Ingénieur en chef du Corps des Mines, Professeur de chimie minérale au College de France, Editor Revue de Metallurgie, and O. Boudouard, Docteur des Sciences. Authorized Translation and Additions by G. K. Burgess, D. Sc. (Paris), Assistant Physicist, Bureau of Standards. Second Edition, Revised and Enlarged. New York: John Wiley & Sons. London: Chapman & Hall. Cloth; 5 × 7½ ins.; pp. xiv + 311; 79 figures in the text. $3.

The first edition of this work was published in 1901 (see Eng. News, Sept. 11, 1902, p. 194.—Ed.). In the second edition the work has been fully revised by the translator at the request of Professor Le Chatelier. The chapter on optical pyrometry has been greatly extended and considerable additions have been made to the chapters on electrical resistance thermometers and electric and gas pyrometers. Brief descriptions have been added of some other pyrometers which have been considerably used in the industries.

The work is a thoroughly scientific treatise on the subject of high temperature instruments. It is suitable rather for the student of physics and for the college professor than for the engineer, but as the engineer is more and more having to do with processes in which great heats are maintained, which heats it is desirable to measure. The book may also be recommended to engineers as beyond question the best one on the subject that has yet been published.

For industrial uses the thermo-electric pyrometer is recommended as the best one now available. For scientific purposes the electrical resistance pyrometer is believed to give the most accurate results. The air thermometer is the standard to which all other thermometers are referred, but its use except as a means of standardizing other thermometers is almost impracticable on account of the difficulty in handling it and its fragility. The author seems to have an antipathy to industrial air pyrometers. He says:

> There is probably no physical instrument which is more difficult to employ satisfactorily and any seeming gain in making direct use of the air thermometer for industrial purposes is only illusory.

He does not seem to be aware of the exceedingly valuable work that has been done by the Uehling-Steinbart recording pyrometer in measuring the temperature of the blast in blast furnaces.

The science of pyrometry is making rapid progress and the author well says that "it is industrial needs that have stimulated the partial solution of pyrometric problems."

The concluding chapter may well be commended to those modern professors who so frequently disclaim on the great merits of pure as compared with applied science. The author says:

> The savants who founded chemistry recognized no distinction between pure and applied science. . . . It is the present trend of our teaching methods that has opened a breach increasing in size every day between theory and practice. In the scientific laboratory all efforts follow in well-beaten paths. . . . One may have confidence for a long time in erroneous results without having any inkling of the error committed. In industrial works it is quite otherwise; one can not remain stationary upon problems already solved; in spite of one's self one must march ahead. . . . These conditions explain how laboratories attached to industrial works with their insufficient personnel absorbed largely in other matters with their rudimentary material come nevertheless to contribute largely to the progress of pure science. All the progress so important in the chemistry of iron is made to-day in the industrial works and in laboratories attached to them. It is not in chemistry alone that practical needs have manifested this creative power. It was in studying the boring of cannon that Rumford met the notion of the conservation of energy. It was in reflecting upon the steam engine that Sadi-Carnot established the basis of thermodynamics; it was seeking to perfect lighthouse lenses that led Fresnel to his investigations of the theory of light.

It is to be regretted that the work does not contain a description of a satisfactory pyrometer for use in testing temperatures of steam boiler furnaces. It is or should be well known that the highest economy in a steam boiler can be reached only when the furnace is at the maximum possible temperature, but the firemen's eye is not capable of distinguishing between the temperature of 2,000° F. and one of 3,000° F., the latter being the temperature which should be obtained for the highest practicable economy. If there were a pyrometer which would indicate these furnace temperatures as conveniently as the steam gage indicates the steam pressures there would be a possible improvement in the economy of average practice of steam boilers which might amount to many millions of dollars per year.

*Dean of College of Applied Science, Syracuse University, Syracuse, N. Y.

COST OF LIVING AND RETAIL PRICES OF FOOD.—Eighteenth Annual Report of the Commissioner of Labor, 1903. Washington, D. C.: Department of Commerce and Labor, Bureau of Labor. Cloth; 6 × 9 ins.; pp. 865; many tables.

In this report Commissioner Carroll D. Wright has brought together a mass of useful statistics bearing upon the cost of living in the United States. The report says that it is safe to assume that the cost of living among wage-workers, in 1903, is less than 15.5% higher than it was in 1890; this percentage representing about the advance in the retail prices of articles of common consumption. Prior to this investigation the only price statistics available were those for wholesale prices; and in the period covered these fluctuated more widely than the retail prices, showing a range as great as 37.2%. The investigation covers 25,440 families, American and foreign, representing 124,108 persons; and it is limited to the families of wage-workers, or those having an income under $1,200 per year. For the whole United States the average annual cost of food per family was $318.20 in 1890, and $342.75 in 1903; this expenditure representing 42.54% of the total family expenditure.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION.—Bulletin No. 57. Chicago, Ill.: L. C. Fritch, Secretary, 1562 Monadnock Block. Paper; 6 × 9 ins.; pp. 68; illustrated.

The report of the Committee on Signalling and Interlocking occupies 56 pages of this bulletin. The report deals with the standard arrangement of signals at interlocking plants, and with the telegraph block and controlled-manual block systems as employed by a number of railways.

THE RELATIONS OF CIVIL ENGINEERING TO OTHER BRANCHES OF SCIENCE.—By J. A. L. Waddell, M. Am. Soc. C. E., Kansas City, Mo. Paper; 6 × 9 ins.; pp. 19.

This is a reprint of an address delivered before the International Congress of Arts and Sciences, held at the St. Louis Exhibition in September. It is of interest not only to the engineer but also to the layman who has but an indefinite idea of what engineering is.

ITEMS OF PARK NEWS.—American Civic Association, Park Department. Hartford, Conn.: G. A. Parker, Box 397. Paper; 6 × 9 ins.; pp. 40. Enclose stamp.

A bulletin with the name given above has been started as a part of the work for municipal betterment of the American Civic Association. This number contains several articles on parks, including a brief report on "Parks of Greater New York," by Mr. N. P. Lewis, M. Am. Soc. C. E. News notes from a number of cities are also given.

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THE STATISTICAL YEAR-BOOK OF CANADA FOR 1903.—Ottawa, Ont.: Department of Agriculture. Paper; 6 × 9 ins.; pp. 773; many tables.

Among the many tables in this volume are a number on population, manufacturers and other subjects illustrating the growth of Canada, based on the Census of 1901.

Publications Received.

HIGH-SPEED ELECTRIC INTERURBAN RAILWAYS.—By Geo. H. Gibson. Condensed for the Smithsonian Report for 1903 from "The Engineering Magazine," September, 1902. Washington, D. C.: Smithsonian Institution. Paper; 6 × 9 ins.; pp. 311-321; five plates.

MICHIGAN HEALTH OFFICIALS.—Proceedings of the Seventh General Conference, at Ann Arbor, Jan. 7 and 8, 1904. Lansing, Mich.: State Board of Health. Paper; 6 × 9 ins.; pp. 112; illustrated.

THE ROADMASTERS' ASSISTANT.—A Manual of Reference for Those Having to Do with the Permanent Way of American Railroads. Second Edition. New York: "The Railroad Gazette." Cloth; 4½ × 7 ins.; pp. 287; 308 figures and 8 tables in the text. $1.50.

SMOKE PREVENTION AND FUEL ECONOMY.—Based on the German Work of E. Schmatolla. By Wm. H. Booth, M. Am. Soc. C. E. (formerly of the Manchester Steam Users' Association), and John B. C. Kershaw, F. I. C. New York: The Norman W. Henley Publishing Co. Cloth; 5½ × 8½ ins.; pp. 194; 75 figures in the text. $2.50.

THE TELEPHONE SERVICE: ITS PAST, ITS PRESENT AND ITS FUTURE.—By Herbert Laws Webb, M. I. E. E. London: Whittaker & Co. New York: The Macmillan Co. Paper; 5½ × 8½ ins.; pp. 118; illustrated. 1s. net; American price, 40 cts.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—Vol. XXI., January to June, 1903. New York: American Institute of Electrical Engineers. Cloth; 6 × 9 ins.; pp. 908.

THE STRATEGY OF GREAT RAILROADS.—By Frank H. Spearman. New York: Charles Scribner's Sons. Cloth; 6 × 8¼ ins.; pp. 287; 11 maps. $1.50 net.

DETAILED DESIGN OF A RAILROAD BRIDGE

By Wm. H. Burr and Myron S. Falk, Columbia University. Paper; 6 × 9 ins.; pp. 54; illustrated. 75 cts.

This pamphlet has been prepared to take the place of considerable matter in Chapter X. and Article 85 of the eighth edition of Prof. Wm. H. Burr's "Stresses in Bridge and Roof Trusses." It presents in detail the process of designing and detailing a railway bridge from assumed data, such as would be furnished an engineer by a railway company.

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Literary Magazines.

One does not expect to find many articles of scientific interest in the midwinter holiday numbers of the popular magazines, given up as they are to art and literature appropriate to the Christmas season. The December "Century," however, has an extended review of the copper sulphate method of treating water, developed by Dr. Geo. T. Moore of the U. S. Department of Agriculture. As our readers are aware, this new process has been fully described in Engineering News, so far as the destruction of algae is concerned; but in the article before us much is made also of the treatment of typhoid-infected waters with copper sulphate. The intelligent reading public appreciates information concerning the important discoveries in science and the notable advances in the arts and industries; but very few will buy and read technical books and periodicals. The "Century" is to be commended for laying so important a subject as that noted above before its readers. We hope, however, that none of them will be misled into placing confidence in copper as a safeguard against typhoid fever until its efficacy has been more widely recognized by sanitarians than is yet the case.

"The End of the Steam Age" is the rather extravagant title of a "Cosmopolitan" article from the pen of Mr. Lewis Nixon. The burden of Mr. Nixon's paper is that the internal combustion engine is to be the future motive power of vessels, gas producers being used in place of boilers, where large power is involved, and liquid fuel on the smaller vessels.

In the "North American Review" British and American naval expenditure are discussed by Lieut. Bellairs of the British Navy. He urges very strongly that the naval strength of the two great Anglo-Saxon nations should be maintained at a point which will enable them united to match the combined navies of all the other great powers. From this magazine we turn to the "World's Work" for December and read there Secretary of the Navy Morton's review of the rapid growth of the U. S. Navy, which has been augmented this year by more new vessels than in any previous year. This paper by Secretary Morton is one of a series in the "World's Work" to which several of the cabinet officers have contributed. The paper by Secretary of Agriculture Wilson is a particularly interesting review of the work accomplished by this important department of the Government.

In the "Review of Reviews" Mr. H. M. Suter writes on the National Forestry Congress which is to be held at Washington, D. C., on Jan. 2 to Jan. 6 next. The Congress is to consider the relation of the public forest lands to irrigation, mining and grazing, with a discussion of National and State forestry policies. This magazine also contains an admirable full-page portrait of Wm. Barclay Parsons with an appreciative account of his work as Chief Engineer of the New York Rapid Transit Railway.

In the "Contemporary Review" for November, we find an interesting account of pioneer work in the field of scientific agricultural research, at Rothamsted in Hertfordshire, England, where John Bennett Lawes in 1843 established the systematic study of problems in connection with plants and soils. For over sixty years experiments have been carried on at this place. It was not till 1875 that the first American agricultural experiment station was started.

The "Nineteenth Century" for November has an interesting paper on the effect of heavy motor vehicles on highways in England. A committee of the Local Government Board has recommended that the limit of weight of a motor vehicle be raised to 6½ tons when unloaded and that when loaded the limit be raised to 8 tons per axle, or 16 tons for a four-wheeled vehicle. In opposing this measure the Chairman of the Roads and Bridges Committee of the Lancashire County Council testified that in a single year £8,000 ($40,000) had been spent in repairing the damage done by heavy motor wagons traveling on the roads between Blackburn and Preston. The writer of the article strongly urges that the weight of motor vehicles be restricted to much lower limits to prevent enormous damage to roads.

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